TEACHERS' MANUAL

for

SCIENCE TODAY AND TOMORROW

Adventuring in Science

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TEACHERS' MANUAL

for Adventuring in Science

SCIENCE TODAY AND TOMORROW

Gerald S. Craig
Katherine E. Hill

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Foreword

Science Today and Tomorrow

During the last twenty-five years, science has grown steadily in the elementary schools of the United States, Canada, and various countries of Europe, Asia, and Africa. This is no ordinary event, for new areas are not easily established in the elementary school owing to the tremendous pressure of various groups to gain the attention of children.

Science in the elementary school has to a large extent been developed by classroom teachers. They have experimented with new activities, new content, and new methods. Many of them have constructed curriculum materials and developed reading materials in science for the elementary school. As a result of this work, instruction in science in the elementary school is uniquely designed for use by classroom teachers.

The new elementary school program with its emphasis on science is a feasible program because it recognizes that the classroom teacher has many professional tasks; teaching science is but one of them. The teacher is a specialist in the education of children and not necessarily a specialist in science. There is no need for classroom teachers to feel any responsibility for specialized science tasks, such as naming all the objects in the environment, animate or inanimate, serving as a field naturalist, as a laboratory technician, or a general bureau of information.

It is evident that only those subjects that are in keeping with the basic purposes of the elementary school succeed in maintaining a permanent place in its curriculum. The American elementary school is a unique institution. It has been called at times "the great common school," in that it is the school for all the people. It was established by the early forefathers as the one institution that would be common to everyone, regardless of race, religion, economic status, and future occupation. It has become the basic institution dedicated to the task of the education of all people for citizenship in a democracy. A significant part of the success that science has had can be accounted for by the fact that elementary school workers have been concerned that science be developed in the interests of *all* boys and girls. This pattern for science in public elementary education is being adopted by a number of democratic countries.

Science from the Developmental Point of View

Science in the education of children should be considered wholly from a developmental point of view. Recognition will then be given to the fact that children do not come to school for the first time at zero in science learning.

They have had a wide range of rich experiences with physical and biological phenomena. They may have a variety of experiences including those with friction, momentum, inertia, magnetism, static electricity, simple electric circuits, snow, ice, water, steam, melting, boiling, freezing, conditions necessary to certain living things, care of animals, seasonal change, the sun, the moon, stars, clouds, mirrors, magnifying glasses, evaporation, condensation, varieties of kinds of locomotion found in the animal world, animal mouths, ears, noses, coverings, balance with building blocks, wagons and tricycles, heat and cold, effects of seasonal change, different animal habitats in the community, solution of solids in liquids, molds, the large number of seeds produced by some plants, and so on. They may bring with them misconceptions and superstitions, or they may come to school with a good attitude conducive to learning and the development of intelligent and resourceful behavior.

Many teachers of children find it useful to accept a point of view of dynamic psychology for understanding children. Their ideas may be stated simply in such words as these: A child lives in a dynamic universe which is new to him. He is challenged by his many experiences. This universe is filled with a great variety of objects. He is impressed by the events (phenomena) small and large occurring about him, such as rusting, rain, weathering rocks, electrical shocks, thunder, wind, and falling objects. He finds himself in normal circumstances tremendously stimulated and turns naturally to exploring and learning.

A young child is naturally egocentric. He is not to be condemned for being so; his egocentricity grows out of his great potentialities for ceaseless drive and for adjustment and understanding of his environment and himself. As a result of the great drives and yearnings, he feels inside himself a whole gamut of emotions which are to him discoveries about himself. He may display grief, irritability, anger, restlessness, impatience, and disappointment. Although such expressions are not to be condoned or encouraged in children, they are

not to be considered in themselves evil, for out of these emotional drives have come many of the great constructive developments of mankind, such as democracy, better living conditions, religious freedom, and improved health.

A child is an energy system and in all the universe we do not find its equal. It is remarkable that out of the use of his energy, a child is becoming intelligent in a universe filled with a vast variety of living and nonliving objects, an almost kaleidoscopic array of events and changes. Within his rapidly widening universe, the child attempts to identify himself and his inheritance. Viewing children from this dynamic point of view assists parents and teachers to understand that the drives of children, which are so frequently annoying to the adult, are potentially constructive traits.

A child learns about his environment whether he is taught science or not, although some of his learning may be negative in value. The kind of science learning considered in this Manual begins in the cradle. As a child begins to separate himself from his environment, he begins to develop learnings based on these experiences. Parents and teacher must recognize that there may be learning about the environment even though a child is unable to state meanings in words. For instance, a child is experiencing something with the rattle he places in his mouth although he has no words with which to shape thought. He is learning something about the earth and its gravity as he pushes his weight against it in taking his first steps. Were the earth like a suspended rubber balloon that bounced away from him, or if the gravity were not constant and pulled him with greater force at some times than at others, he would develop a different set of attitudes and behavior. In considering science in the program of elementary education, it is well to conceive of science experiences as beginning with birth. In a real sense, the adjustment to the environment can be traced back to the prenatal stages.

In a very real sense, we might say that the potentialities of science are inside human beings. To make it more personal we may think of these potentialities as being in such human beings as ourselves—teachers and children in the classroom. This is true because science has grown out of a tremendous urge on the part of mankind through the long centuries to come to an understanding of the universe.

Man, from the remote past, has sought explanations for the things that happen in the world about him. The rainbow, birth,

death, life, lightning, and other events challenged him. He frequently used great ingenuity and much fancy to develop explanations for the phenomena about him. The myths and legends of many peoples indicate men have felt that if they could understand the world about them they might know more about themselves, their origins and history. The fact that primitive people frequently associated their explanations with their religious beliefs demonstrates how important such explanations were to them. In fact, these explanations had much to do with man's adjustment to the environment. Sometimes man's explanations made him fearful and superstitious; at other times they filled him with confidence, calm, and resourcefulness.

According to the developmental point of view, the origin of science is in man's distant past. An implication of this for teachers in the elementary school is that science need not be thought of as something foreign to them or to the children they teach. Science as we know it today, with its discoveries and inventions, is the result of urges in men and women through the ages. We can see these same urges in children as they follow their natural drives and as they attempt to secure adjustment and equilibrium in a dynamic universe. They use the senses of smelling, tasting, feeling, seeing, and hearing, the kinesthetic sense, imagination, curiosity, energy, irritability, restlessness, play, response to external conditions, and other partly understood drives deep within their natures to project themselves into the areas of the environment. They depend upon impulse, fancy, creative activities, and logical thinking just as their ancestors did.

From the developmental point of view not all of science is difficult. On the contrary, from this point of view science is part of the earliest learnings of children. Furthermore, the technical, vocational, and specialized aspects of science have no function in elementary education. Elementary science is closely related to the experiences of children and to the kind of thinking they can do, so that teachers need have no fear of science. The teacher can learn the science that is needed while teaching science at any level in the elementary school.

The fear of science felt by some adults is not usually found in children. The adult may have been conditioned to a dislike of science in part by previous contacts with science instruction at high school and college levels, whereas children, having felt no such condition-

ing, are still following their natural impulses. Teachers can free themselves from their negative reactions if they will attempt to see the environment and science through the eyes of children. Encouraging children in a classroom to express themselves freely about their ideas of natural events has assisted many teachers to understand children and at the same time to gain a new look at the world for themselves.

Using Science in a Democracy

There has grown up a conviction that the free nations must remain strong if they are to remain free. There is also a realization that there is power in science, and therefore that science is an essential element in maintaining and improving the democratic way of life. It will not be enough to have a small portion of the population educated as scientists; to be truly strong, an entire nation must be conversant with science. To realize this goal, science must be placed in the curriculum as one of the fundamentals. Making a whole nation conversant with science is a task uniquely suited to the elementary school since this is the institution of all the people. It is the institution which has in its enrollment not only the future scientists but laymen as well (everyone is a layman outside his special field).

Strength for free peoples is secured through the development of good living conditions as well as military defense. Through the use of science man can do much to shape his own future, since science has tremendous potentialities for the improvement of living conditions for all.

The children now in the elementary schools will live in a world of tomorrow. Our boys and girls will live in a time of great decisions. They will need to make certain that science will be used for good and not for evil. They will need to determine how democracies can be kept secure. There will be great problems concerning the use of new and old sources of energy. Theirs will be the problems of wise utilization of natural resources, the distribution of new synthetics, medicines, and drugs, provision for health and well-being, development of materials from new sources, establishment and maintenance of research agencies dedicated to public welfare, the establishment of a balance of nature that will provide ample food and recreation for all, and the creation of a stable economy based on the natural

resources and other problems to be solved, all within a democratic framework. Through all of this there will probably be a consideration of problems of international and world co-operation.

As we seek to determine what shall be the basis for our instruction in science in the education of children, we find we must look to something more permanent than a mere teaching about objects. We make this decision because in a few decades we ourselves have witnessed a vast array of new inventions displace objects which once seemed permanent. Kerosene lamps have given way to electric lights in many places. We have observed the transition from telegraph to television. Our familiar world is in constant transition. So, although we may utilize objects in teaching children, we cannot base our curriculum on objects. We must look deeper for our basic purposes.

Some might say that our major purpose is giving children content. But the content of science, important as it is in the education of children, does not constitute the fundamental purpose of including science in the elementary curriculum. This is true, first, because our basic purpose must be in terms of children and society, and consistent with the dedication of the public elementary schools to the principles of democracy. Second, as we shall see later in this introduction, we must recognize that the content of science is not absolute; what we think is reliable information today may need revision tomorrow.

What we can be certain of is that boys and girls will need to be resourceful and democratic in the decades ahead if their and our way of life is to survive. Therefore, we are concerned with the development of resourceful and democratic behavior. If we succeed, we shall not need to be unduly concerned for the future, for with the development of resourceful behavior in accordance with the high purposes of democracy, our boys and girls can use science to shape the future with complete confidence.

It is to be noted in this discussion that science is considered as a tool for humanity. There is no intent in the education of children to develop science for its own sake or to defend science as a vested interest. Only as science serves in the development of children and in the welfare of humanity can it be defended as essential in the education of elementary-school children.

It is most important that we recognize that boys and girls need to do much more than talk about science. If democracies are to

preserve their way of life, there must be in their populations the ability to operate intelligently and resourcefully with the materials and energy of the universe to the best interest of mankind.

Social studies, however valuable they may be, are not sufficient in themselves to help children meet and solve the problems of today and tomorrow. Teachers and school systems are likely to miss the great contributions of science to children and through the children to the larger goals of democracy when they place science in the curriculum as a segment of the social studies. Science grows out of the tremendous urges of the human organism and does not have to be motivated through social studies. Many students of children think that science by its very nature is more challenging to young children than social studies. This is not to be interpreted as an argument against the social studies. It is, however, an appeal that curriculum workers thoroughly think through the concept that science is a part of the development of children. If properly guided, children can grow in intelligent and resourceful behavior just as they can grow physically if properly nourished.

Some have suggested that the primary purpose of science in the education of children is to develop "little scientists." Such an idea is not consistent with the fundamental purpose of the elementary school and the origin and nature of science in society. There should be no hero worship of scientists except in so far as an individual scientist deserves it. Democracy will be weakened if a society is created with a distinct scientific class. Scientists serve, but so do soldiers, senators, artists, carpenters, barbers, farmers, doctors, and everyone else. Scientists now and then outside their own special fields are somewhat naive, and at times exhibit traits of gullibility and dogmatism, thus violating the fundamentals of science. Scientists are human beings like other people. We should not set up the lives of scientists as ideals for children to follow, regardless of how much we may appreciate the contributions of science.

The Nature of Modern Science

In science we do not view knowledge as absolute. Any statement of science can be challenged, revised, or refuted with suitable data. There is no room for dogmatic attitudes. There can be no dictator for science.

Through science, man strives always for a better understanding

of the world. Unfounded prejudices, opinions, gossip, rumor, astrology, myths, intuition, and superstition cannot be considered reliable sources.

Science is an active, dynamic field, constantly demanding willingness to make new observations, to repeat experiments, to consider new facts, and to challenge earlier conclusions. Science is far from a finished subject; in fact, it is likely that it is only in its beginnings. All the areas of science are undergoing changes as a result of continuous study. New ideas are being added and old ideas revised about stars, ventilation, living things, diseases, nutrition, and other areas of science.

Man learns through experiences by means of his senses. Science has produced new instruments, such as telescopes, microscopes, and others, that extend man's range of observations and experience. Nevertheless, to explain many happenings in nature, even everyday occurrences, is exceedingly difficult in spite of many new technical tools. So scientists have been forced to develop provisional explanations, or hypotheses, to guide them in further study of some things. But scientists must abandon any hypothesis as soon as it is found to be unsatisfactory. There is much that scientists have not satisfactorily explained. Many times a scientist must say he does not know even about problems within his own field of specialization, and even though he may by all rights be the world's leading authority on the problem involved.

Since man is continuously in the process of making new discoveries and revising his information, accuracy is not an exact status. This means that we do not teach a fact as though it must be true for all time. It indicates, also, that we cannot teach all the truth to a child about any single subject. We may, however, attempt to make certain in the classroom that the way in which a child learns is consistent with scientific attitudes.

We cannot hastily call an item correct or incorrect. Instead it is essential that in all our discussion, reading, experiments, and so on we determine what is the most reliable information at a given time. It may not be as serious a matter to be mistaken in the information we may have at any time, as to assume that there may be no need to secure new information on all important matters throughout our lives. It is also a serious matter to pass along information as if there were no question about its accuracy when we are not sure of its re-

liability. The nature of modern science is thus entirely consistent with the idea that learning takes place through the continuous growth and development of large concepts. It also indicates how necessary it is to view education as a process which takes place from the cradle to the grave.

Accuracy is a direction toward which man in his best efforts strives. It is also a goal toward which teachers and children can move in teaching and learning; it calls for growth for both teachers and children. A child's ideas gained from science can be accurate in so far as they go, but as a child proceeds through the school, his knowledge about any one subject increases in amount and detail. In other words, we may not be able to teach children all the reliable information in science about a given subject, but what we do teach can be consistent with what is reliable. Authoritative books such as those in the SCIENCE FOR TODAY AND TOMORROW series can be most useful to both children and teachers in maintaining a high standard of accuracy and sound development of attitudes.

Science and Behavior

This condensed description of the nature of science has been provided because it has many implications for the teacher and can provide him with a sense of security and adequacy in teaching children. The teacher has the right according to science to play an honest role in the classroom. He has a right to admit that he is learning; that he makes mistakes sometimes; that sometimes a child with a special interest and concentration may be learning faster than he is. In a real sense, the scientific method is a method of honesty, and neither teacher nor child should be penalized in any way for being honest. The learner should never be humiliated for the admission of ignorance. The implications of science for mental hygiene and human relations are profound.

It would be well for the teacher to consider the implications of science in the development of such behavior patterns as open-mindedness, critical-mindedness, and the avoidance of gullibility. There is no greater educational factor operating in the modern world than the attitudes that teachers and parents utilize while working and living with children.

In science it is important to state the source of one's comment in explaining a phenomenon, such as evaporation of water, hiberna-

tion of animals, erosion of soils, and so on. For instance, one might say, "I read an explanation in . . . ," or "It may be . . . ," or "My father said . . . ," or "On my way to school I saw . . . ," or "I think it might have been," or "I used my imagination," or "I think I am right," or "I can do an experiment to show . . . ." This is preferable to giving such information as if the statements were unquestioned facts. We have sometimes called this identifying the source of a comment. The teachers and children should develop the behavior pattern of identifying the source of a comment.

Both teachers and children have a right to use their imagination, to speculate, to repeat information as long as they distinguish between reliable and unreliable information. Such a behavior pattern is in the direction of assuming responsibility for one's own speech. It is quite different from the behavior of gossip, loose talk, and rumor spreading.

This type of development should not be allowed to harm the good human relationships of children. Frequently children use parents' opinions as reliable information. It would be well for the teacher to handle such comments in a manner that will in no way decrease the child's respect for his parents. In a sense, the attitude of the teacher may be that we are glad to have what the parent has said, and indicate that further development of the statement is given in authoritative books. Perhaps the comment might be "What do persons who spend their lives studying this kind of thing say?" Science instruction should be utilized to improve the human relationships of children, those of children with children, children with teachers, and children with parents.

It is obvious that the great behavior patterns growing out of science are not built in a finished manner in a day or a year or a decade. For instance, critical-mindedness and open-mindedness require time for development. Development of the patterns associated with resourceful, democratic behavior should be considered a continuous program throughout the elementary school.

There is considerable evidence that three great achievements of mankind—democracy, scientific method, and religious tolerance—developed contemporaneously and out of the same general struggles. An examination of these achievements will indicate that these three have much in common in basic meanings. In the opinion of many students, real science cannot exist outside a democracy.

The Content of Elementary Science

Almost everyone is impressed with the extensive nature of science; it has indeed grown tremendously in scope. No one can learn all of science in an entire lifetime. It is also obvious a teacher cannot teach it all. Only a very small portion of the total science will be taught to children, but that portion can be most important in the development of citizenship. The question of how much content of science is taught is not of nearly so great importance as is the question of what content of science is taught and how it is taught. With the world situation as it is today, it is most important that the content and procedures of science suggested to teachers and children in such a series as SCIENCE TODAY AND TOMORROW be those designed for the preservation and advancement of democracy.

Because of the extensiveness of science, there has been a tendency to develop what might be called encyclopedic instruction. Under this method students have been required to learn wide areas of content. Comprehensive instruction has been developed about animate and inanimate objects and about topics in the environment with little sensitivity on the part of curriculum makers as to the value of the content to the teacher and children involved. In the encyclopedic type of instruction the purposes of science in elementary education became lost in small content and busy work.

A traditional trend in nature study has been to make science instruction dependent upon an incident approach. If a child brings in an object, such as a rock, a feather, or a flower, or if he can relate an interesting experience, then there is instruction in this field about the object or incident. If there is no object or no incident, there is no science instruction in such classrooms. Science becomes incidental and accidental in the classrooms of teachers holding to this point of view.

But science is no incident in the lives of children. In fact, it is and probably will continue to be one of the most dominating and decisive factors in the lives of children. Schools developing science on an incidental basis will not provide boys and girls with the education they need for the great decisions they must make for themselves, their country, and the world.

This is not to say that incidents have no place in teaching-learning situations. Natural incidents can be used as experiences for concept-

formation and for the development of understanding of phenomena. But science with its profound and challenging ideas has a great contribution to make to the formation of concepts and important ideas. If our democracy is to survive, we must make certain that the potentialities of science in our way of life will be developed. This instruction must not be incidental.

Since the best information scientists have at any one time will need to be revised in keeping with future discoveries, a content of science in the elementary school cannot be considered as set and fixed for even a few years. There are, however, certain patterns for the universe which seem to persist as profound descriptive principles for all time, in spite of revisions and modifications that follow new discoveries. These patterns are described in the following statements:

a. The universe is very large.

b. The earth is very old.

c. Many changes are going on in the universe.

d. Living things are interdependent and interrelated.

e. Living things which are living today are the results of adaptations that have been made in the past.

f. There is a great variety among living things.

g. There is evidence of a tendency toward balance among the forces and living things.

For the sake of brevity, we can speak of these patterns as principles of space, time, change, interrelationships, variety, adaptations, and balance.

These patterns seem to be guide lines for instruction through the elementary school. A child can continue to grow along the lines of these great principles or patterns. The experiences an individual has throughout life can enrich his understanding of these principles. Man must recognize these patterns if he is to adapt his civilization to this universe. A knowledge of these basic patterns is necessary to the understanding of the world's problems and life's experiences in our modern democratic world.

The Large Patterns of the Universe as Guide Lines for Teaching-Learning

The Universe Is Very Large—Space

As man has studied the universe that surrounds the earth, he has become impressed by the immensity of space. The earth which he thought was very large and the center of everything is small compared with many other objects in the universe. This earth is one of several bodies which revolve about a star known as the sun. The sun is one of millions of stars which compose a vast galaxy of bodies which is called the Milky Way. Man has learned that there are many other galaxies within range of the modern telescope.

While a complete understanding of the immensity of space is undoubtedly beyond the mental capacities of any one individual, it can become a guiding factor in the interpretation of the experiences of children at all levels. The young child may begin his growth in the understanding of space as he begins to associate with himself the rooms in his home and the yard or immediate vicinity about his home. Later, he learns the location of the nursery school or kindergarten when he is taken there by adults or by school bus. Still later, he goes to school by himself and learns where the homes of his relatives and friends are in relation to his own home. As he travels to neighboring communities, his world becomes larger. He may be intrigued by the observation that the sun and moon seem to follow him as he moves about.

A child's early contact with this pattern may merely teach him that the earth is a very big place compared with his familiar neighborhood. He may become acquainted with the appearances of the day and night sky. Later, his learning will reveal that the earth is very small in comparison with the stars and space. About the same time he will also learn that the stars are suns which are very, very far away. In later years he increases his understanding of the vastness of space by learning about the extent of the solar systems, the Milky Way Galaxy, other galaxies, radio stars, cosmic rays, the light year, and so on.

Any adult who has read modern astronomy, has attended lectures in this field, visited an observatory or planetarium, or considered the possibilities of space travel knows that his conception of

space continues to change after childhood. There are new, challenging thoughts for all levels—the junior high school, senior high school, and college levels—and, for that matter, many new discoveries still to be made by the astronomer. Some comprehension of this conception is essential to an appreciation of the significance of science in its revolutionary effect on modern thought. It is important that children should be started properly along this path rather than allowed to absorb inaccurate and unscientific ideas of the universe and astronomical bodies and to grow up with earth-centered conceptions in an age of modern science.

The Earth Is Very Old—Time

The conception of the great age of the earth and of the universe has come to mankind as a revolutionary idea. Not only has it profoundly influenced scientific understanding, but it has altered man's attitude toward his own place and function in the universe. It was natural for primitive man to think that the earth had been formed just a short time before the advent of his people. Much of this primitive belief came down into modern times and still controls thought in scattered areas. Children in their early years may learn that soil is made from rocks, and through activities, observations, and experiences discover that the process of soil formation took a long time. They may also learn something about the forces which operate upon the earth to produce changes; that it was a long time before the earth became a suitable place for plants and animals; and that many kinds of animals have lived on the earth and have become extinct. These ideas furnish him useful content in constructing his understanding of the great age of the earth.

Children may have a variety of interesting experiences with earth forces: for example, they may examine pavements broken by water freezing in winter; feel rocks softened by the action of weathering; observe erosion after a rainstorm; note how plants keep soil from eroding; examine different kinds of soil with a magnifying glass.

Time is something to be learned. Children must learn the concepts of yesterday, today, and tomorrow; the meaning of a second, a minute, an hour, a week, a month, a season, and a year; the sequence of seasons; the varied lengths of life of living things. A tree may be several hundred years old, and on the other hand, a mouse may live only a few months.

Time is relative to both children and adults. A half hour may be a long time waiting for a plane or train, but very short if we are playing. A year between birthdays can seem a long time, but it is short in terms of the centuries the Indians have lived in the Western Hemisphere. The teacher and the parent can greatly enlarge children's concept of time.

In later work children may learn something about what has happened to the earth, the causes of natural features in various localities, the long ages of prehistoric life, the struggle of life for existence, the forces operating on the earth, and some of the changes that have taken place on the surface of the earth. This comprehension of the great age of the earth is essential to an appreciation of the antiquity of man and of man's attempts to build social institutions for his own welfare. The goal is not the memorizing of a chronological sequence of events, but rather an approach to the modern conception of time. These ideas reveal to man the importance of building his social and political structure with the thought that he may live on this planet for some time to come, provided he uses his intelligence to assure survival. These concepts are fundamental to building an understanding of what is intelligent utilization of natural and human resources. This understanding is necessary for man's planning for his own future.

This background to an appreciation of the modern concepts of time and change should tend to inhibit chauvinism; it should teach each pupil that all life existing on the earth today is the result of a long succession of living things—a development involving a vast number of individuals and extending back to the beginning of life on the earth.

The mountains, rivers, valleys, plains, seas, and other physical features that we think of in connection with a given nation and that often come to be revered by the people of that nation have not always been there as they are now. The surface of the earth has changed its appearance many times in the past and is constantly changing today.

As the result of a long series of experiments in the art of living, man has become a dominant force in nature, and we have a right to feel a pride in the achievement of all mankind. It must be emphasized in our instruction that this achievement is restricted to no one race or nationality.

Changes Occur Continuously in the Universe—Change

The conception of change permeates all fields of knowledge, and man must consider these changes if he is to operate intelligently with natural forces. Modern geology reveals that our physical environment does not remain constant, that the history of the earth is a story of change—change in climate, in topography, and in the succession of living things.

The conception of change is manifest not only in geological history but in living things, as, for example, the changes produced by birth, growth, age, and death. There are also changes produced by the biological principles of struggle for existence; and these cannot be ignored by man in his striving to adapt the world to his needs. Then there are the changes produced by energy and movement. Astronomical bodies are seen to have changed position and character through cycles of time. The scientist learns to look for change in his explanation of phenomena; the layman must expect change as a condition of everyday life; the student of social studies and the citizen must anticipate change in the political, social, and economic structure. Information concerning changes produced by physical and chemical phenomena developed in terms of children's own experiences can be introduced during early school years and continued through later levels.

Children see water disappear from a dish by evaporation. They pick up rocks which have weathered so much that the rock disintegrates into small pieces in their hands. They see the changes in the sky, in the weather, and in seasons.

Illustrations of change include such phenomena as rusting of iron, melting of ice, boiling of water, weathering of rocks, variations of weather and of seasons, and innovations produced by man's discoveries and inventions.

School windows should be utilized more fully for the study of the succession of changes due to weather, to the seasons, to the time of day, and man's activities in relation to these changes. Brief excursions around the school ground will provide varied experiences depending on the region. The children may see frozen, muddy, and dry soil; the growth of plants; and a variety of plant structure, such as roots, stem, flowers, and seeds. An outdoor thermometer may reveal temperature changes. Art work can be utilized in the study of changes.

A community of living things never remains in a strictly static condition. Children can observe the changes in a weed patch near the school, in the thicket, or in a garden. There is a continual shifting caused by weather, seasonal change, and just ordinary life and growth within the cycle of new life, maturing, and death. All around children are evidences of change.

There is no exception to the occurrences of change even when man is involved. Natural forces are always present and working in an environment. Perhaps man can never control the natural forces. Rather he must learn to work intelligently with these natural forces to bring about changes which are advantageous to his best interest.

In addition, there are the great changes brought about by man's inventions and man's discoveries. Of course, children are not so aware of the significance of these changes as adults. However, the school must prepare children to meet change, for the next generation may need to be prepared for even greater changes than those met by the present generation of adults.

Man has lived through revolutionary changes in his social living because of the introduction of new forms of energy and of ways to utilize that energy. The discovery of fire, the introduction of animals to carry man's burdens, the steam engine, the electric generator, and the internal combustion engine greatly changed man's social and economic conditions. The utilization of atomic energy is bringing and will continue to bring tremendous changes. Children should gain a feeling of confidence in the fact that they are not the first of the human race to witness revolutionary changes in energy. Furthermore, it might be well for us to know how man's discoveries of new forms of energy have brought about great potential supplies of energy for everyone. The advances in the field of agriculture and soil culture may have significant impacts on the future course of world events.

Changes brought about in a community also may be significant. What did the country look like before the earliest settlers came in? What changes have been brought about by man?

There are less than a hundred natural elements which enter into combinations and form the multitude of substances about us. Chemists find that some of these elements combine in so many different ways that to date they have been able to make but a small proportion of all the possible combinations. Chemists are learning to build

out of cheap sources substances which in their natural states have been very rare. They have also learned how to make new substances, such as new drugs, insecticides, medicines, plastics, synthetics, and so on. In this way, science contributes greatly to an improved health, finer recreation, and higher standard of living.

Life Is Adapted to the Environment—Adaptation

Adaptation is a pattern which permeates the entire realm of living things, for wherever there is life there is adaptation. This is a conception of great significance in the modern world. Indeed, man's problem today is to adapt his social, economic, and political structure to the conditions of the environment and his own needs. In the early grades children can learn something about the homes of some animals and their adaptation to life in various places. They can be introduced to the idea that animals' structures have become modified to fit their environment. Later they can learn how plants and animals, including man, are adapted to seasonal changes. The study of prehistoric life is a story of adaptation, and can be supplemented by a study of how animals are protected against their enemies, how animals take care of their young, and how plants continue to live on the earth. Man adapts himself through community life. The advantages and disadvantages of this form of adaptation, along with a study of solitary animals, may be considered on intermediate levels. As the child matures, the scope of his concept of adaptation is further broadened through a study of prehistoric modifications, of the weapons which animals use, and of the struggle for existence.

The conception of this pattern, like the conceptions previously outlined, may influence an individual at all levels of his development. It may modify the child's interpretation of simple observations of the effect of seasonal change on plants and animals. It may give substance to the youth's understanding of the structural variations of living things, and to his consideration of problems of public welfare. It may determine the adult's participation in politics and in public forums. The scientist finds much that remains to be discovered concerning adaptation. The significance of this conception in the social studies can scarcely be overemphasized.

Some of the more general facts involved in understanding the concept of adaptation are the relationships of living things to tem-

perature, water, food, light, gravity, and certain gases found in the atmosphere; the effect of some of the limitations of these conditions upon life; the narrow range in these conditions on the earth as compared with those found in the universe as a whole; the adaptations imposed upon plants and animals that live under these conditions; the prolificness of life; and the interchange of energy and substance between plants and animals and between the physical environment and living things. Through experimentation, discussion, and reading, children learn that living organisms need light, oxygen, nitrogen, carbon dioxide, heat, water, and other conditions in order to exist and to produce young. When some of these things are scarce or too abundant, life may suffer.

The implication for international understanding is that man frequently is limited by the physical conditions of the environment to which he adjusts himself. Some people must live in inhospitable places, such as swamps, deserts, and arctic regions. These people must utilize the materials that are available for shelter, food, and clothing. It is not surprising, therefore, to find among the peoples of the earth a wide variety of customs. Many of these customs which seem foolish to others may be the results of the experiences of many generations in a given environment and may be necessary to the survival of that people.

International co-operation has become a necessary adjustment on the part of mankind if our culture is to survive.

In science studies in the elementary school, children have an opportunity to realize that man is only one of a multitude of living things, and that, like these other things, he has survived because he has made adjustments and adaptations to the environment.

The Variations of Living and Nonliving Things—Variety

On the earth there are wide varieties of climate exhibiting differences in mean temperature, in the range of temperature, in the length of the growing season, in the amount of rainfall and its seasonal distribution, as well as differences in exposure, in slope, in drainage, in elevation, and in soil. These factors create many kinds of environments and require adaptations to these environments. All around us we see in nature a variety of forms, differences in structure, sizes, habits, and life histories of plants and animals. They range from the ultramicroscopic organ-

isms to the gigantic forms of the redwoods and whales. The life span of some living things is very short, while that of others covers several hundred years.

When we see how many different kinds of living things there are, it is not surprising to find that there are also so many different kinds of people. Man has wandered about the world for thousands of years, living in many habitats widely separated from each other. We should expect, therefore, to find different races, languages, and customs, but a concept that science may teach is their interdependence despite their differences.

No two living things are exactly alike, although they may be of the same species. We cannot, therefore, judge all people of any nation on the basis of one or two we may have known.

Variation is manifested in the physical world as well as in the biological. There are many systems of organization in the physical world—the atom, the element, the molecule, the compound, the substance, the planet, the solar system, the galaxy. There are many kinds of minerals, soils, and rocks. There are less than one hundred natural elements; there are thousands of different compounds. There is variety in the manifestations of energy. Man, too, tends to develop variety of forms in his inventions, discoveries, engineering, and arts.

Children should become acquainted with this theme by being introduced to the range and scope of certain obvious characteristics in the physical and biological aspects of nature. Instruction should be chiefly concerned with the theme rather than with mere identification of animate and inanimate objects.

Each child has two parents. Each parent brings to the child a diverse inherited background. When we consider that this means for each child four grandparents, eight great grandparents, and so on, the tremendous potentialities working for variation in the human race become apparent. When to this observation we add the fact that each child has a different environment, the tremendous variations found in children in any classroom are understandable. Every individual is a result of success through a long span of years in that each of his ancestors is the result of two parents reaching maturity in spite of sometimes hazardous conditions.

The concept of individuality, that each individual is unique and different from all other individuals, is a part of the larger pattern of

variety. Williams,[1] a biochemist, has recommended that we should start teaching children in the kindergarten that they possess individuality. His recommendations merit serious consideration by elementary-school workers. They point to one way in which science can contribute to mental hygiene. Each individual has a right to be different. He should not be amazed to learn he is superior to some of his classmates in some ways and inferior to others in other abilities. This pattern can be used to develop a feeling for the dignity of the individual, a feeling so important in a democracy.

Following are some of the aspects of variations that are illustrative of those found in the environment of children:

a. Changes that take place in the out-of-doors.
b. The many different kinds of animals.
c. The variety of animal noses, eyes, tails, mouths, legs.
d. The variety in prehistoric animals.
e. The different ways in which animals move about.
f. The differences in animal homes, such as those on the desert, in the arctic, in swamps, underground, in fresh water, on the seashore, in the ocean depths, in the forest, in the meadow, in trees.
g. The variety in locomotion, food-getting, breathing, and protection of animals.
h. Different ways in which animals grow up.
i. The different kinds of plants, such as those that develop from spores, those that develop from seeds, those that are annuals, those that are biennials, those that are perennials.
j. The animals that are social, and those that are solitary.
k. The animals that are cold-blooded, and those that are warm-blooded.

Interdependence of Living Things—Interrelationship

This is an illustration of a theme which is practically universal in character. We see the significance of interrelationships as an integrating theme in many of the forces operating on the earth, for example, in the description of astronomical bodies, weather, and other physical phenomena; in the interdependence and interrelation of living things to each other and,

[1]Roger J. Williams, *Free and Unequal: The Biological Basis of Individual Liberty* (Austin, University of Texas Press, 1953), p. 177.

in turn, to their physical environment; in the causes of ill health; and in the relation of pests and parasites to economic loss in the agricultural world.

Space does not permit a full discussion of how the idea of interrelationships in physical and biological phenomena may be developed. In the early years children gain experiences which lead to an understanding that some plants and animals in the garden are harmful. In later work they learn the value of certain other plants and animals and what people are doing to protect them. Attention should be focused in later elementary school work on the problem of conservation and on preparing pupils for a more comprehensive study of the biological principles involved in the struggle for existence, in the balance of nature, and in the interdependence of life. Some of the relationships of scientific discoveries and inventions to man's progress and welfare should be considered. Man does not live to himself alone. He lives in a world of interdependencies and interrelationships. He is dependent upon earthworms and plants for the fertility of the soil. He is dependent upon the birds to keep the insects in check. He needs snakes, owls, hawks, and other animals to keep rats and mice in check. Spiders serve to control the number of insects. An animal which seems rather insignificant to us may play an important role in the development of conditions suitable to man.

The interdependence and interrelationships of living things to other living things and of living things to the physical environment is basic to the understanding of social issues. Physical and biological forces do not recognize national borders. A wind blowing in one country may be due to world-wide atmospheric conditions and the pressure of air in regions within the borders of other nations. Animals do not necessarily stop at national borders unless those borders are natural barriers, and even then certain animals are known to cross many such barriers.

In science the earth must be considered commonly as an entity; a disturbance in the physical or biological world in one part of the earth may have significance to many other parts. In a community a fire in one section is the concern of the entire community. A disease or a pest in one section of the world may become the concern of all peoples. Nations, therefore, should learn to work together in an intelligent way for the welfare of all peoples of the earth.

The natural resources of a country, such as soil, oil, coal, gas, forests, and pastures, are the result of natural forces operating for millions of years. People have not created them, but they frequently waste them through carelessness and mismanagement. Man can waste in a generation or two what has been the result of titanic natural forces operating over long periods of time.

Man, if he is to remain civilized, must disturb the original balance of nature, for only savagery can exist where man does not attempt to make changes. But it is man's task to use the natural processes and resources in such a way that he secures what he needs for a high standard of living without hazarding the welfare of future generations. Man need not return to savagery nor disregard natural resources; he now has science to use in planning for the years ahead. It is incumbent upon the public schools to develop a generation with ability to meet its problems, both personal and social, with intelligence, co-operation, and resourcefulness. This calls for an appreciation of the interdependence of living things, and of the interrelations of living things and the physical forces and materials.

Balance and Imbalance—The Interplay of Forces

As one observes the many events or phenomena in his environment, one is impressed by the dynamic flow of events and the energy involved in them. If one could be an observer over centuries, one would be aware of the titanic forces in operation; but seen one day at a time over the short span of a human lifetime these forces often pass unrecognized. Some, such as evaporation, seem small, yet scattered over the face of the earth, evaporation is tremendous and results finally in rain, snow, dew, frost, weathering, erosion, floods, blizzards, and other events.

There seem to be tendencies toward equilibrium and balance in the operation of forces. In a normal atom it is thought the positive electrical charges balance the negative electrical charges. It is thought that a static electrical charge is the result of an imbalance in these electrical charges. The shock we feel or the lightning flash we see is the resulting establishment of equilibrium of these charges. Even the thunder can be thought of as a clap caused by air rushing in where the air was expanded by the heat of lightning.

We have already spoken about the balance of nature. Man has

been ruthless at times with this balance and has experienced economic loss from the resulting dust bowls, soil erosion, waste of resources, epidemics, plagues, and pests.

There are forces operating also in the structure of the earth. It is thought by some geologists that in maintaining balance these forces have caused the formation of mountains, continents, and oceans. We witness earthquakes and volcanic eruptions as a part of the balancing of the earth's structures.

It should be kept in mind that the sun is a great source of energy and that it shines on the earth all the time. It shines on the other side of the earth while we are having night. It shines, when it is cloudy, although there are clouds between us and the sun. The sun then is like a great solar engine which furnishes energy for green plants to grow and make food, for water to evaporate, and for the movements of air currents or wind and of ocean waves. The movements caused by the sun's energy are checked and modified by the earth's gravity, its rotation, and to some extent by friction. There is a tremendous interplay and interaction of the forces in the universe.

Wherever we look we witness the operation of forces and the many evidences of balance. In our own efforts to maintain balance and equilibrium, we also experience the operation of natural forces in and on our own bodies. Many psychologists explain learning at all levels as a process of attempting to gain intellectual balance in the face of a new situation, a problem, or a challenge.

Conservation as a Pattern for Behavior—Developing Responsibility for Our Environment

As children develop a better understanding of the basic patterns of the universe, they also may acquire more intelligent behavior with reference to natural resources, including human resources.

Some courses of study help to establish undesirable kinds of behavior, as when children are encouraged to develop collections which in turn can rob the environment. Sometimes they are instructed to bring to school collections of leaves, twigs, flowers, rocks, minerals, and bird nests.

We need to develop in children a feeling of responsibility for the environment. Conservation, or intelligent use of natural resources, consists of a kind of behavior as well as a body of content. Before moving objects, animate or inanimate, out of the environment and

into the classroom, there are many major considerations which the children may discuss. To whom does the object belong? Do I have the right to take it to school? Do I disturb the environment if I remove this object from it? Am I destroying the natural beauty of the environment by removing this? Is the study I am going to make of the object one which merits its removal from the environment? Should I plan to return the object to the environment as soon as the study is completed? Can this object be studied properly if it is removed from the environment? Can I care for it properly in the classroom? If it is alive, does it have a chance to live in the classroom? Am I prepared to give it the care it needs to survive? One should keep in mind that living things are usually found in an environment to which they are more or less well adapted.

Developing Behavior Consistent with Health, Economy, and Safety

Many schools are now integrating health entirely with science and the social studies. Science provides the necessary background for the teaching of health information and the development of good health habits; therefore, a program of science in terms of problems and meanings should offer opportunity for the integration of science and health.

The relation between science and economy has too long been neglected. Because of his own ignorance of the operation of biological and physical principles, man is at present beset by a host of problems concerning international economy. Recent projects in a number of countries are helping to solve these economic problems in local environments by re-establishing in the natural forces a balance in favor of man's interests and welfare.

The relation of science to the economic problems of man is well exemplified in his struggle with pests. Man has carelessly introduced exotic plants and animals into almost all regions of the world. Many of these transplanted plants and animals, unchecked by their natural enemies and competitors, have multiplied so rapidly that they have brought havoc to the economic life of the nation. Control comes not alone from the work of fact-finding public or private scientific agencies, but also from the intelligent co-operation of the entire population. Much can be done to secure this intelligent co-operation through an integrated program of education in the public schools.

Mankind cannot afford to have another generation ignorant of the elementary biological principles of nature.

Another similar problem is to find ways to prevent loss of soil through erosion. In almost any section of the world we can find examples of the terrific loss of natural resources resulting from the lack of soil conservation. Creating an awareness of this problem in order to bring about intelligent individual and community action concerning it is no small part of science in the elementary school program.

Many species of our indigenous plants and animals have become extinct because of man's ruthlessness and ignorance. Still others are in danger of being destroyed. Man cannot continue to be ignorant of the web of life in which he is by nature involved. The elementary school, as the tool of the common people, should work toward developing a generation concerned with the wise utilization of natural beauty and resources.

We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible for us to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well for us, then, in safety instruction, to place more emphasis upon scientific principles which are basic to safe conduct. Children at all levels should be encouraged to enter into planning with the teacher for safety on all excursions, including the short excursion, even though it may be only to the edge of the school ground.

Consideration should be given to what one should do in case of fire or other disaster so that the behavior is automatic. Classroom teachers and parents can have a powerful influence over the destiny of whole regions and nations by developing in children a willingness and ability to base their conduct and behavior upon sound information. Safety education, as one aspect of the goals of conservation, can well be integrated into the development of responsibility for one's own behavior and for the environment.

A Variety of Procedures

The teacher should look to a variety of procedures in teaching science. It might be well to avoid dropping into routine methods. Discussion, instructional excursions, observations, experiments, reading, use of visual aids, group work, and planning all play a part

in the teaching-learning situations in science education. The teacher should consider her own interests, tempo, and rhythm along with those of the children. It is important that the teacher be happy with the procedures. It is well for the teacher to be present as a participant in all the procedures. He should be a learner, for good teaching in science involves learning.

If there is one term that can be used to specify the kind of instruction appropriate to all phases of science teaching in the elementary school, it is "developmental." In this case it is developmental from the point of view of children and teacher, both as learners. It means the instruction develops, using the experiences and knowledge children may have or that can be provided for them. It is developmental in that children may participate in the development of the planning for the use of experiences, experiments, discussion, and authentic materials to provide solutions to problems. The new learning is made acceptable to the children by the nature of its development in instruction. Children are given time to internalize new learning, integrating it with their experiences and ideas. It is important in this development to provide opportunity for an idea to be tossed about in the thinking of a group, to be tested through simple experimentation, if appropriate, or through observation, to be talked about at home, and to be checked against authoritative books.

In any consideration of teaching methods, the primary concern in elementary education is what kinds of boys and girls are being developed. All of us need to be cautious that our procedures do not become devices and ends in themselves. Therefore, evaluation should be an integral part of instruction rather than something done at the end of a period of instruction.

At all times in teaching it is well for the teacher to know at what point the children are in a given development. In this Manual suggestions are given the teacher as to ways in which he can secure this information. It is well also to find out how the children think, that is, the type of thought structure they have. Such questions as "What do you think?" "Do you think so? Why?" "Why do you say that?" "How would you get the information?" "Do you think that is information we should accept?" will give the teacher evidence as to how children think and where they are in their development.

Regardless of how the instruction at any point is initiated, vital teaching recognizes the concepts children may have on a subject or

problem. So it is well for the teacher to provide opportunity for them to express their ideas, however incomplete or inaccurate, in order that misconceptions may be brought into the open. It is most important that they be allowed to express themselves without the fear of censure or ridicule, although at times there can be the enjoyment of childish humor and fun without personal damage.

Very frequently children's concepts have originality and imagination. Their concepts also provide opportunities for evaluation of preceding work and reveal the kind of instruction needed for the clarification of ideas. The authors of this series have profound respect for the natural ideas developed by children. Every child needs an adult who will sympathetically and intelligently listen to him. If such a person could be provided for more children, we would need fewer corrective institutions.

Studying Children while Teaching Science

Teachers will find their teaching enriched if they will study children as they teach. Science with its challenging content and its rich contribution to the attitudes and behavior of both adults and children offers unique opportunities for the study of children.

The greatest concern in studying children is not how much information children have secured, important as that may be. Rather, the main emphasis should be on what kind of boys and girls we have. What kind of thinking do they do? What are their outlooks upon the world? Are these outlooks constructive and democratic? Do the children think for themselves? Are they developing good ways of thinking? Are they learning to be resourceful?

At all times teachers should be alert to the kinds of behavior changes that children are making. The teacher may ask: "Are the children developing dogmatic attitudes, or are they willing to consider new ideas? Are they tending to accept every idea they hear without hesitation? Do they look for further evidence before drawing conclusions? Are they learning to use authoritative books? Do they report on out-of-school experiences in a wholesome way? Do they propose explanations? Are they learning to plan? Will they work with others?"

In this kind of study it must be recognized that behavior may reflect the home and the general background of the children. A dogmatic parent may cause a child to be gullible.

It should be kept in mind that it is the behavior in which a child has had some degree of freedom of choice which is the most useful for evaluation. The closely worded or directed question of the quiz program and the rigid recitation have little significance in evaluating behavior. In a sense it is the spontaneous behavior of children—the proposal of something to do, the inquiry, the choice of language in indicating open-mindedness, the critical-mindedness, poise, resourcefulness, the challenge of a statement, the willingness to consider new ideas and to take on new duties, the use of old learning in new situations and learning—which is useful in evaluation. All of this seems to favor a type of discussion in science instruction which allows for freedom of expression and thinking.

It is recognized in this that teachers need to study children as individuals and as groups and from a total, rounded-out point of view of education. The contention here is that science with its profound meanings offers unique potentialities in studying children from this view. Children should not be evaluated as if the development in behavior relating to science were isolated from all other aspects of their lives. Science, as the interpretation of the environment, should be thought of as an intrinsic part of the life of children in the modern world, a part that may be an important factor in building desirable behavior.

A Dynamic Education for Children

The preservation and advancement of democracy depends to no small extent on the behavior patterns developed in children. We do not know what the future will be. In a sense we must educate children for uncertainty. This does not imply that we need be pessimistic about the problems these children will face in the future. Rather, we can be confident that if we assist them to develop democratic and resourceful behavior, they will make their own future.

It is the contention here that the outlook of children toward their environment and universe is the very core of the development of a resourceful adjustment to the future. While incidents play an important part in making learnings meaningful, science should not be incidental in the lives of children. Instruction limited to talking about science and a description of objects and events is not in keeping with the dynamic urges of children and will not serve to help them cope with the problems of today and tomorrow.

There is a need for a positive and dynamic program for children, one which develops a feeling on the part of children of being needed by our democracy, in times of peace as well as war. Children are needed not alone for their own nation but to assume responsibility for work toward a better world.

There may be opportunities for children and teacher to work to improve conditions in the classroom, in the school, on the school grounds, and in the community. In this way, they can see how science is used.

Science will continue to play an important role in the lives of our children. It is a powerful tool which can be used for good or evil, and children, the adults of the future, will have to decide which way it shall be used.

It is most important to the success of our way of life that children have a favorable attitude toward science. Science should not seem foreign or exotic to them. Science viewed as the result of the age-old drive of mankind to adjust himself to his environment and to maintain his own equilibrium in the welter of biological and physical forces carries with it a larger point of view than a purely vocational one. Science is the result of man's experience and logical thinking through the centuries. Science, like democracy or the mother tongue, belongs to all who wish to make use of it. Children should be made to feel that science belongs to everyone.

Science instruction should be a pleasant experience for both teachers and children. Teachers should feel relaxed with children while teaching it. Interest in science should be maintained at all levels. The instruction should be freed from busy work and the meaningless drudgery types of assignments. Exhaustive and overly specialized units should be avoided.

Boys and girls must learn to handle and to experiment intelligently with the forces and materials of the universe. Unintelligent tampering and carelessness bring disease, ugliness, waste of natural resources, unemployment, poverty, war, and widespread unhappiness. Children must develop a poised, well-balanced, yet realistic outlook upon the modern world. They must learn that by working resourcefully and intelligently they can create their own world.

GERALD S. CRAIG

Children and Science

Children nine and ten years old are eager adventurers in their environment. They are active, curious, alert, co-operative, responsible. You will want to make the most of these abilities of children as you help them to clarify their ideas of the world in which they live. You will want to encourage children to make use of material from the area of the natural sciences as they set about the business of enlarging and clarifying their concepts of the world around them. *Adventuring in Science* has been written with these thoughts in mind; therefore it presents materials concerning such things as plants, animals, the sky, weather, soil, electricity, heat, and chemicals.

This Manual has been prepared to help you as you work with children in the solution of their problems. Each chapter in *Adventuring in Science* has a parallel chapter in this Manual. In each chapter of the Manual you will find additional information which may be of help as you work with the parallel chapter in the children's book. You will probably want to read the manual material before using the book in order to recall facts, as well as to have additional information and ideas in mind.

In each chapter of this Manual there are suggestions for teaching, for additional experiences, and for evaluating. Please note that these are *suggestions*. It is hoped that as you prepare to use each chapter of *Adventuring in Science* you will constantly keep your group and your community in mind, and that you will plan and work with your children in terms of their abilities and of their environment. The suggestions presented have been found to be successful with some groups of children, but they may be of little value in your particular situation. In other words, you will use your initiative and the initiative of your group in working through an area of experience. This Manual is not a book of tricks. It is intended to pass along to you, the understanding teacher, some of the good ideas which have been collected from many other teachers in many different communities.

What to Teach and When

The question of what to teach and when to teach it is often considered by teachers as they discuss curriculum materials. So far as science is concerned, a general answer is: "Help children experi-

ence their total environment." This means that science learning should not be limited to one area, such as the sky, for an entire semester. During a year's time, children should have experiences from the following areas: bodies in the sky; the earth, its rocks, its soil, its air, its water; plants and animals; air, water, light, heat, and their influence on plants and animals; man's understanding and use of nonliving aspects of the environment, such as gravity, heat, sound, electricity, light, magnetism, and chemicals.

Each year children should have the opportunity to explore with ideas and materials in each of these areas so that more varied and more mature understandings will have a chance to emerge. We know that concepts are built out of individual experience. Each child's concepts differ. Each child's concepts are built over long periods of time and emerge from real and vicarious experiences. It is our business to provide a rich environment for learning, an environment which is extensive enough to encompass every child in a group, an environment which constantly stimulates concept formation because of the challenges offered.

To limit a group of children to the study of one area in the broad, fascinating field of science is to do that group an injustice. You will want to give children as much challenge as they need, and be willing to work and learn with them in new avenues of experience.

It is difficult to indicate how much time should be allowed for science, since the lengths of the school day and year vary from community to community. At certain times of the year, near Christmas perhaps, less time may be devoted to science because of intense occupation with other areas of learning. At other periods during the year, more attention may be devoted to science experiences.

The question is often raised as to how this time should be allocated during the week. Again the answer varies. Let us assume that your science program is one in which children engage in total-group, small-group, and individual activities. Then the total group should assemble for sharing, planning, and evaluating several times during the week. The remainder of the time for science would be devoted to exploration and sharing in small groups. Perhaps several small groups will work on science materials simultaneously. On the other hand, only one group may engage in a science activity while other groups are at work with language arts, social studies, or arithmetic materials.

It may be that your group works almost entirely as a total group, rarely engaging in individual or small-group activities. If this is the case, it probably is well to have rather frequent science periods. When such a plan is followed, there is likely to be greater continuity in children's planning and thinking. If science experiences occur as seldom as once each week, children tend to lose the continuity of their science activity and become frustrated and disinterested.

Selecting an Area for Study

In teaching science, as in teaching any other content area, we want to help each child grow in his awareness, initiative, appreciation, clear thinking, responsibility, and co-operation. Just as the wise teacher provides space and materials which may be used in various creative efforts, she also provides opportunities for real living; she provides rich problem-solving opportunities.

Children want to learn. This may seem a trite statement, but, indeed, it is the fundamental philosophy of the successful teacher. Even though children do want to learn, they learn effectively only if they accept the problem to be tackled. At times this acceptance occurs because the problem for investigation comes from a child's proposal. On the other hand, the teacher may propose a problem and have that problem genuinely accepted, especially if the teacher is a valued member of the group. Merely telling children to work out a problem does not make for its acceptance and hence for wholehearted effort in its solution. Nor does voting on the problem insure its acceptance. There must be a period of exploration, time for proposals as to plan of attack, suggestions of possible solutions. This planning or exploring is an integral and valuable part of the learning experience. As such, it should not be hurried.

When the time comes for the choice of a new topic for investigation, either at the beginning of the school year or at the completion of study of a problem at hand, provision should be made for a pooling of ideas. The most natural method for this pooling of ideas and exchange of experiences is through group discussion.

Suggestions for study will come from individuals, out of the background of their experience. These suggestions might be written on the board by the teacher or by one of the children. Care should be taken to record each suggestion just as it is given. If suggestions are

edited, valuable clues as to a child's correct ideas or his misconceptions may be lost. Children should elaborate upon their suggestions somewhat so that the entire group gains some idea of the interesting possibilities involved. Of course, the teacher should not hesitate to offer suggestions for study.

If this way of working is new to your group, the children may not be able to formulate their suggestions readily. In that case, you will want to stimulate group thinking. One way to do this is through experience outside the classroom.

A walk through your building may bring to mind such problems as "How does the electricity get into our building and then into our room?" or "Why do we always have meat, vegetables, fruit, and milk on our lunchroom menu?" A walk around the school grounds might bring such questions as "Would seeds grow in this soil?" "How were these stones formed?" "Will it rain this afternoon?" or "Why does the moon have different shapes?" A walk through the community may bring such a question as "Has our town always looked as it does now?" A visit to a nearby pond or stream or wooded area or meadow area will arouse many questions concerning the plants and animals living there.

Before setting out on an expedition of this kind, it would be wise to discuss the purpose of the trip. Each child should understand that he is to look for things about which he might like to discover more information.

Another method of stimulating group thinking in the choice of a problem is through examining books. Gather together as many different science books as you can and use them with your children in a browsing period. The thinking of the children will be stimulated for they will find problems for study which had not occurred to them before.

After suggestions from the group have been written on the board, they should be studied for possible grouping. Such questions as "Why does the moon have different shapes?" "What is a shooting star?" and "Could you fly to Mars in a jet plane?" might be combined under the larger topic "The Bodies We See in the Sky."

When the grouping of problems is completed, the final choice of a topic must be made. Such a choice needs real consideration and must not be hurried. Sometimes it is wise to delay the final choice for a day or so until the children have had a chance to think, read,

and talk about the possible topics. During a final period of discussion the group can reach a consensus as to its choice of topics.

Searching for Answers

Finding satisfactory solutions to the problems involved in the selected topic is the next step. Accurate information needs to be gathered from many sources. This may be an individual responsibility, or it may be the responsibility of small groups. Perhaps it is well to recall at this point that important objectives in any learning situation are: increased co-operation, increased individual initiative and responsibility, and increased skill in locating and applying pertinent facts. Planning and research provide opportunities for continued growth in these directions.

The next step for the total group or for its committees is to work out a plan of attack. The topic selected for study should be broken into its subproblems, each of which may require the active research of the total group, of committees, or of individuals to find their solution. Here the teacher again becomes an active guide, drawing on her wider experience in helping children organize their ideas and plans. Out of her background of experience in the solution of problems, the teacher will suggest various methods of discovering information, such as using printed materials, audio-visual aids, and resource persons, doing experiments, and taking excursions.

Reading · Through reading, children discover the ideas of others. It may be well for children to approach a science book with a definite question in mind. Children thus read for information, for further ideas which may be used in the solution of a problem.

Sometimes children attempt to solve a problem through extended argument or by voting. A wise teacher helps her group to understand that argument does not solve a science problem, although discussion helps to define the problem and clarify ideas concerning it. A wise teacher also helps children understand that a science problem cannot be solved by voting. One such teacher led her group to understand that the question "Is this salamander a reptile or an amphibian?" could not be solved by vote, but that it could be answered by gaining information from reliable source books.

Authentic, authoritative information is needed by children. They should be helped to judge the worth of source material. The date of publication, authorship, and other factors should play a part in the selection of reliable reading materials. Furthermore, children need to learn early that some science problems cannot be answered positively. Consequently, they may find in several sources conflicting theories concerning their problem. In addition, sources may vary in regard to such a question as "How many moons has Jupiter?"

A science table and materials for science experiences in the classroom provide an effective means of acquiring science meanings.

owing to the fact that additional information may have been discovered after publication of some of the source material.

The suggestion that children read to find new ideas about their environment can be stimulating to the children and lead to profitable science activities. Another source of ideas for study may be current happenings as reported in the news. The group alerted for ideas to explore will discover many science topics for study.

Experimenting · Another way to gain information is through experimenting. Perhaps it is better to say that children experience rather than experiment. *Adventuring in Science* offers suggestions

for many experiences with simple materials. These activities are not real experiments. An experiment is carefully controlled; it is carried out under known conditions.

Children's "experiments" too should be as carefully controlled and as carefully worked out as possible. However, children should be cautioned to check the outcome of their activity with a reliable source, such as an informed person or reliable source material. Or they may repeat the experience a number of times to determine if the results are always the same.

Jane Coons

The experiment to produce the chemical compound carbon dioxide is one which the children can check by repeating it. **(See page 82.)**

Inclusion of the checking step in each experiment cannot be emphasized too strongly, since it is inherent in the correct solution of a problem. You will want to help children firmly establish the habit of checking.

The experiences suggested in *Adventuring in Science* were worked out as carefully as possible. Help your children to work through these experiences with real materials which may be gathered from school or home. Merely reading about the activity is rarely satisfying to children. You too will enjoy working through these experiences and others proposed by the children or by you. Participating in science experiences is another important method of gathering information; it is a vital way in which to learn.

Excursions · Some of the most valuable learning situations occur outside the classroom. A trip to a wooded area will build very different understandings than will result from reading or studying pictures.

Excursions should not be thought of as long trips or "special" occasions. For instance, the trip may be only a short walk around the school grounds so that the children may observe the buds on trees and shrubs. Or the trip may be a walk through the neighborhood to determine how many different animals can be seen. Or the trip might be a visit to an excavation which is being made for a house or larger building in order to observe the layers of rock and soil beneath the surface of the ground.

There are numerous experiences outside the classroom which can be used. It might be interesting for you to make a list of such possible experiences. Note which of these experiences you have used. Which ones could you use?

When an excursion is taken for the purpose of gathering information, the purposes of the trip should be worked out carefully with the children. Each child should know what he is looking for; each child should grow into a more and more careful observer. Some children will want to record their on-the-spot observations either through note-taking or by sketching.

It may be well to keep in mind that children's observations do not always provide reliable information concerning a phenomenon. Again, as in the case of experimenting, children should check their "facts" with reliable authorities.

When the group returns to the classroom, almost always there is need for discussion, since the solutions to some problems will have been found and new problems will have arisen. Some children will want to make a record of observations at this point; others will want to verify observations by checking with reliable sources; others will be eager for additional data. There should be time for absorption and for sharing of ideas. This is an essential part of the total excursion.

Resource Persons · Children should be helped to realize that the ideas found in books come from people. They need to understand that the printed word itself is not necessarily reliable, that they need

to consider the qualifications of the person who puts his ideas into writing.

It is important that children learn to value the ideas and information held by people in their community. Here is a grandfather who was born and has lived all his life in this community. He is a valuable resource person because he can tell how the community has changed. He can show where a stream once flowed, where a wooded area stood, where a fine farm existed.

Perhaps there is a father or mother who is a physician. Such a person may be willing to come and help the group better understand why we need to eat certain foods.

Another parent or a friend may be a traveler and a photographer. Perhaps that person would be willing to share his pictures and his information with the group.

The gardener, the keeper of tropical fish, the custodian who is able to trace the electrical wiring in the building, and many other members of the community may be used as resource persons.

At times these people should be invited into the classroom to share their information with the group. At other times it is more convenient for the group to go to the resource person. If you make a survey of such resources in your community you will find many opportunities to use them.

Audio-visual Aids · Today there is a good selection of lantern slides, filmstrips, and films which are suitable for use with elementary-school children. Many of these deal with subjects from the natural sciences. Some of the available films are listed at the end of each chapter of this Manual.

Perhaps you are fortunate enough to teach in a school which has a budget covering the purchase and/or rental of such materials as these. Perhaps your school system has a film library.

Films and filmstrips are available for school use from many state departments of education and from some universities. Find out if such film services are available in your state or province. Secure a catalogue if one is available and make yourself familiar with the routine involved in selecting and securing these visual aids. A list of commercial rental agencies that have educational films is included in the Appendix.

Museums in your city or in nearby cities often have visual-aid

materials which you may borrow. This is also true of government agencies. Again, equip yourself with catalogues listing materials available from these places.

Libraries in your school, in your community, or in museums often have mounted pictures which may be borrowed for the use of school children.

Mounted exhibits such as those showing the life cycle of a butterfly, samples of wood from trees growing in North America, and examples of various rocks and minerals are often available from museums. These are usually loan collections which may be used free of charge except for postage fees. Such materials should be used freely.

There are still other sources of visual materials. Some schools maintain a school museum in which models, collections, mounted specimens, and pictures are displayed. Fresh exhibits should be arranged often by various groups of children. A school museum must not be static, dusty, and moth-eaten. When it begins to enter this state, its usefulness is certainly to be questioned.

Trips may be arranged to view the collections made by people in your community. Inquiry may reveal excellent collections of such things as shells, rocks, minerals, butterflies, and moths. If it is at all possible, take your children to visit nearby museums frequently. They should go to get information, to check conclusions, to open new avenues of interest.

Just as films and other visual materials are available, so are recordings. When you are studying animals, it would be valuable to listen to the recorded songs of birds. Make use of tape recordings also. Have you thought of asking a group of children or a teacher living in a different part of North America to exchange recordings describing interesting aspects of your respective communities? Use the tape recording, printed material, and visual materials—all three—for a better understanding of the question at hand.

Teachers need to open to children as many ways of learning as possible. Certainly, audio-visual materials offer much in the way of gathering and using information.

Using Materials · Equipment, such as jars, spoons, pans, magnets, and dry cells, should be stored so that it is readily available to children and so that it can be kept in order easily. You may want to

set aside a portion of a closet or a cupboard for such materials. Or you may want to use open shelves for this purpose.

An adequate space for using these materials should be available also. Perhaps this space could be a linoleum- or oilcloth-covered table. Here children may use materials without fear of damaging other table or desk tops. Here material may be kept for several days while children are experimenting with it.

Are you making the best possible use of bulletin boards? Sometimes you will arrange an entire bulletin board with pictures and articles to arouse interest in a new area or contribute to learning in the area under consideration. The display will make use of attractively mounted, well-spaced visual materials. Its title will indicate the topic illustrated by the bulletin-board display.

At another time, your contribution to the bulletin board may be only titles, such as "Animals Which Once Lived in Our Community" and "Animals Which Now Live in Our Community." The children may be encouraged to supply the pictures illustrating the ideas.

At other times, the children will take complete charge of the bulletin board. You will help them to plan an effective display. They will think of appropriate titles, gather material, and arrange it so that the material has meaning.

In using films, slides, or filmstrips, many teachers find it a successful practice to allow time for viewing such material a second or even a third time. If a film is available for one day only, you may want to arrange your program so that it may be seen a second time on the same day if such a procedure seems wise.

You will seldom show visual materials or use auditory aids, such as tape recordings, without having previewed them. Even though this is a time-consuming process, it pays dividends.

Evaluation

Evaluation is an integral part of the learning process. Children should consciously have a part in evaluation. Indeed, evaluation is part and parcel of well-rounded experiencing.

From time to time, the total group or committees or individuals need to pause and take stock of their progress. They need to make further plans. It will be important to decide which ways of working were good and which need improvement. They will want to decide

which experiences were of value, whether some need to be repeated, and whether fresh experiences should be sought.

Again the teacher steps into the picture as a guide. She places much value on the process of evaluation and knows that true evaluation cannot be concluded rapidly. Therefore this important business is given status in the program of the day or week by making time available for it.

You will want to de-emphasize competition among children in the acquisition of facts. For this you will want to substitute a challenge to each individual to use his best talents in acquiring knowledge for some use. You will want to emphasize the growth in ability to locate, organize, apply, and share information rather than the memorization of facts.

Children can be helped to appraise their own growth in these matters. Some children will keep folders with samples of reports which they have written. Others may want to keep notebooks with illustrations as well as written explanations. Some will want to make individual science dictionaries or make contributions to a class dictionary. Groups of children may want to share ideas in oral or in dramatic form. Children may be helped to be aware of their own progress in such activities as these. Self-evaluation must be an ongoing process.

Teachers are constantly aware of individual reactions in various situations, and many keep a running record of these so that an overall evaluation of individual progress may be made from time to time. By doing this, it is possible to become aware of a child's progress in the direction of those goals which were mentioned at the beginning of this introduction; namely, the goals of keeping curiosity alive, becoming more alert, growing in responsibility and co-operation, enlarging concepts, and developing skills inherent in solving a problem.

Fostering individual development is one of the most important jobs of the teacher. Helping children to use the area of the natural sciences in this development can be a challenging, a stimulating, a joyous experience.

I

Plants Are Protected

The plants growing in your community and in communities all over the globe are living things. Often these plants are thought of as living things only during the spring and summer when they exhibit rapid growth. Upon more careful consideration, however, it is apparent that many plants are alive all through the year; that plant communities survive from season to season; and that plant families survive from generation to generation. "Plants Are Protected" presents material which may help children become more aware of plants that grow in their immediate communities and to learn about those in distant communities. It is hoped that as children become more aware of plants they will make wiser use of them.

Science Meanings for Children

No teacher can ever envision all of the learnings which may come to the individuals in her group as a result of experiencing a particular area of science. This is because each child is a unique individual with a unique background of experience and purposes. Some children gain many new meanings from an experience; others gain few. This is because each child must incorporate a new meaning into *his* background of experience.

Some of the science meanings which children may gain from this chapter follow:

Plants are living things.

Tough stems are a protection for some plants. Having many seeds or many spores is a kind of protection for certain plants. The scattering of seeds is another method by which some plant families live for many years. Some plants are protected by spines, stings, poisons, or armor. Roots and leaves play a part in plant protection.

People have learned to protect plants.

Information for You

There are many kinds of living things, but they may be divided into two large groups, plants and animals. All living things are protected in some way, but man is the only living thing capable of reasoning concerning his protection against temperature changes, food shortages, inadequate clothing and shelter, and enemies.

Plants are protected in many ways. This chapter discusses tough barks and tough stems as protections. A tough bark resists insects.

Warren W. McSpadden

Germinating beans in an open pan allows children to observe the development of roots, stems, and leaves.

Tough stems support plants, thus holding leaves in a position to receive light. The stiff stems of plants, because they make poor food for cattle and other animals, also offer protection.

Many plants, such as dandelions, produce numerous seeds. Since many of these will never germinate, having numerous seeds helps to assure germination of some for a succeeding generation.

Some plants, such as mushrooms, produce spores. Few of these spores grow into new plants, but there are always new spore-producing plants because a few of the spores produced germinate. Ferns,

mushrooms, puffballs, and molds produce spores rather than seeds. Each of these plants produces many, many spores, thus assuring germination of some.

The seeds of many plants are shaped in such a way that they can be scattered easily. Maple, elm, pine, and ash seeds have wings which allow them to be carried greater distances by the wind than they would be if they were without sails. The silky threads of milkweed, cotton, and thistles serve a similar purpose. Seeds with sails often stay afloat for some distance after falling into a stream; thus they may be carried to a place far from the parent plant. The thick, fibrous, waterproof covering of a coconut seed causes it to be light enough to float; thus these seeds may be carried by ocean waves from island to island. Birds and other animals also are responsible for scattering seeds. Again, this scattering of seeds is a protection for plants, since in this way the seeds may reach a place more favorable for germination than the region directly beneath the parent plant.

Plants with stings, spines, poisons, and armor are protected from possible destruction by animals. Thus, they live longer and produce more generations of plants.

Roots and leaves are also protective devices. Root systems grow deep or wide-spreading or both. These root systems balance the portion of a plant above the ground. They are the water-intake system for a plant. Numerous wide-spreading roots act as rapid intake systems after rain. Deep-growing roots absorb water from moist subsoil. Many leaves shelter a plant's root system from the full force of the rain and thus prevent soil erosion to some extent. Plants living in arid climates often have few leaves. Since water is given off from a plant through its leaves, a scarcity of leaves means that less water is given off and the water reserves of the plant are protected.

People have discovered that it is necessary to protect many of our plants, especially the more beautiful wild varieties. Your state or province will be able to supply a list of plants which your local authorities have asked you not to disturb. People also protect plants by pruning, gathering seeds, covering with netting as in the case of tobacco plants, and so on. Talking to gardeners and farmers in your community will reveal many other methods of plant protection by people.

Ways of Working with Children

This chapter is independent of all others in *Adventuring in Science* and may be used at any time of the year. Either fall or spring probably would be a better time for this study than winter, however, since it may be difficult to locate the seeds, spores, leaves, stems, and roots of plants in the winter.

Perhaps you will introduce the study of plant protection by taking a walk with your group. Children in urban areas may observe plants in a park near them, or they may observe plants in vacant lots, or they may observe trees and other plants growing along a street or on the school ground. Children in suburban areas may observe plants on their own school ground, in nearby gardens, in parks, and many other places.

The first walk may be exploratory in character. You might go in search of an answer to the question "What are some ways in which plants are protected?" You and your group may discuss this question after your return to the classroom. Let the children propose answers based upon their observations. You, the guide in this study, will help children realize that these observations do not always provide accurate information. There is reason to observe again and again, to check observations and conclusions against the observations and conclusions of others, and to refer to accurate books for information.

Examine the picture on pages 4 and 5 of *Adventuring in Science* with your group. Notice that the trees have many leaves, the goldenrod has many flowers which produce seeds, the oak trees produce many acorns, and so on. Ask the children how having many leaves and many seeds may be a protection for plants.

Help the children recall the tough-stemmed, thick-barked plants they saw on their walk. Take another walk and observe these plants again. Emphasize the point that plants do not consciously protect themselves. These living things are protected, however, in the ways mentioned in this chapter.

As you deal with protection by seed production, by type of seed, by poisons, stings, spines, and so on, take your group into the outside environment again and again. Observation and discussion on the spot pay enormous dividends.

Materials Needed

bread	magnifying glass or	mushrooms	saucer
lemon	hand lens	orange	seeds

You Might Try These Things

See suggestions for children, page 23, *Adventuring in Science.*

1. Help children practice good rules of conservation. Take only one seed of each kind. It is unnecessary to identify each seed; you might classify them very simply as suggested on page 23 of *Adventuring in Science.*

2. Help children share information with others in their group, with older children, and with younger children.

3. In finding such information, you may help children contact local and national departments or bureaus of conservation. Use one of the films on conservation of forests suggested at the end of this chapter.

4. Sometimes children and adults believe they are immune to these plants. Apparently, our bodies change from year to year so that we are susceptible some years and not others. It is wise to know these plants and be cautious concerning them.

Further Activities

1. Try a germination experiment to understand better why producing many seeds helps plant families survive for many genera-

The experiment shows that enough beans sprout to ensure the survival of the species.

tions. Count out 100 corn, pea, Lima-bean, squash, or lentil seeds. Cut blotting paper to fit into shallow cookie or pie tins. Moisten one sheet of blotting paper and place seeds on the paper. Cover each pan with glass or blotting paper and set the pans aside so that direct sunlight does not reach them. Keep the paper moist. In a few days the seeds will begin to sprout. Note that not all the seeds sprout. This will help children see that although all seeds do not sprout, a sufficient number do to keep corn or beans or peas growing year after year.

2. Count the number of seeds in a milkweed pod, in a sunflower, or on an ear of corn. How many seeds some plants produce!

3. Help your group open a coconut. If the coconut still has its fleshy, fibrous, air-filled outer covering, try floating it in water.

4. Plant seeds of the same plant, such as corn or Lima beans, in various ways. Put some seeds in clay, an equal number on a brick, in water, and in fertile soil. Water the seeds equally and give them the same amount of light and heat. This may help children see that having many seeds helps plant families survive, since some seeds may fall in places where they do not grow well.

5. On a walk, note the odor of skunk cabbage and the bitter taste of the "milk" of a milkweed plant.

6. Put sunflower stems and leaves, pine needles, lettuce, fern leaves, horsetails, and celery in a rabbit's cage as food. Notice that the rabbit does not eat the tough, stiff foods.

7. Examine a fresh pineapple and notice its stiff, sharp leaves. Notice the armorlike skin of the fruit.

Was It Worth While?

This is a question which you might ask of yourself after each science discussion. The process of evaluation then becomes a part of the total program, an aid to you and your group in further planning, a method of stocktaking. Since evaluation is related to purpose, it is difficult for an outsider to determine whether an experience was worth while for you and your group. However, some of the following evaluative procedures may be helpful to you if they coincide with your purposes.

1. Did you enjoy this study of plants? Did the children enjoy it? If enjoyment was not present, what was wrong? How can future study be improved?

2. Ask children to write a few sentences listing the new ideas which they gained from this study. Since you know your group well, this information may help you to clarify the ideas of individuals in your group. You will also be able to determine why these learnings are significant.

3. Subsequently you may note whether the children apply their learning to new situations at later times in the year. For instance, are they spontaneously careful of poison ivy when they are taking a walk?

4. Is each child taking sufficient responsibility concerning materials? Does he bring materials as he promises to do? Does he clean up without prodding? Does he help keep the science materials in order?

5. Perhaps your group might like to plan an exhibit bringing out the meanings gained from this experience. Observe individuals as they plan, as they use source material, as they check their exhibits for accuracy. Are they more conscious of man's relation to plant life? Help children to move forward in these directions.

6. If you have stressed conservation of plants in your discussions, the children may profit by working individually to prepare rules concerning plant protection. Then the children might pool their ideas to prepare a set of rules. These rules might be recorded on a chart which could be posted in the hall or in some other prominent place in your school. As you help an individual work through his list of rules, you will be able to determine his learnings on this important subject. Following are some of the ideas which you may want to see incorporated in the class list of rules on plant protection:

Ask permission of the owner to pick a flower or leaf.

Take only one flower, seed, or leaf when preparing an exhibit.

Know which wild flowers should be protected in your region and learn to recognize these flowers.

When taking a leaf or flower, cut it carefully so as not to injure the plant.

7. But even more important than making and knowing conservation rules is practicing these rules. Do the children break off leaves and twigs as they walk beside a hedge? Do they run across the newly-sodded school lawn? Do they pick rare wild flowers on their way to school? Or do they suggest that the entire group go on an excursion to observe and enjoy flowers in their natural setting?

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Films

Flowers at Work. (EBF) 1 reel, b/w. Makes effective use of close-up and time-lapse photography to show the pollination of flowers by bees. Explains the functions of seeds.

Forest Conservation. (EBF) 1 reel, color. Tells of the ways in which man has destroyed forests and urges good forest practices in order to conserve this valuable resource.

Fungus Plants. (EBF) 1 reel, b/w. Describes the growth and reproduction of mushrooms and other fungi. Gives close-up views of spores and gills; shows poisonous plants.

THE GROWTH OF FLOWERS. (Cor) 1 reel, color. Describes the life history of a rose, an orchid, a jack-in-the-pulpit, a daffodil, and an iris. Shows in ten minutes processes that take place in about ten weeks.

LIFE OF PLANTS. (UW-Govt) 1 reel, b/w. Depicts by means of time-lapse photography the germination of seeds and how roots, stem, leaves, and flowers develop.

PLANT TRAPS. (EBF) 1 reel, b/w. Shows how the sundew plant and the pitcher plant entrap and use insects for food.

ROOTS OF PLANTS. (EBF) 1 reel, b/w. Different kinds of roots are shown, together with experiments demonstrating root growth, food intake, and sensitivity.

THE SEASHORE. (Barr) 1 reel, b/w. Shows how plants and animals are adapted to living in shallow sea water. Tidal-pool life is viewed closely.

SEED DISPERSAL. (EBF) 1 reel, b/w. Shows methods by which seeds are transported. Shows dispersal by animals, wind, and propulsion from seed cases. Depicts natural methods of seed protection during germination.

SOW AND SOW. (ALF) 1 reel, b/w. A graphic visualization of the continuous process of seed dispersal and plant reproduction.

WONDERS OF PLANT GROWTH. (Churchill-Wexler) 1 reel, color. Two children grow bean and squash plants under varying conditions. They also discover that new plants grow from stems and roots. Time-lapse photography is used.

Filmstrips

BEHAVIOR OF PLANTS. (Curr F) color.

II

Heat Causes Changes

Around us much energy is constantly at work. Heat is one form of energy which affects us every hour of every day. If you are to help children become both more aware of and more understanding of their environment, such a form of energy cannot be ignored. "Heat Causes Changes" is a chapter which emphasizes "doing." It is written as a guide in experiencing certain phenomena connected with heat energy. But is serves as more than a guide in experiencing; it aids also in interpreting aspects of the environment.

Science Meanings for Children

It would be unrealistic to expect every child in your group to incorporate each of the following meanings into his background of experience. But each child should be encouraged to broaden his horizons, to deepen his vision, to lift his sights in accordance with the meanings which he has and with those presented to him as a challenge to his thinking.

Some of the science meanings in this chapter follow:

Heat can be so great that it can melt rocks. Heat can change ice to water and then to steam.

Liquids evaporate when they are heated, thus changing into gases. Some liquids evaporate more rapidly than others. A liquid cools the place from which it evaporates.

When a substance is heated, it expands; when it is cooled, it contracts.

Small particles of a substance are called molecules. Heated things expand because the molecules of which they are made move back and forth more rapidly than they do when they are cooler.

Cool air contracts and moves downward, thus pushing warmer air upward. Cool water contracts and moves downward, thus pushing warmer water upward.

Heat travels through steel. Heat travels from molecule to molecule through solids.

Cooled water vapor condenses to form droplets of water. Rain, sleet, hail, dew, frost, or snow may be formed when water vapor condenses.

Frozen things are solids; frozen things can be melted.

Information for You

Heat is a form of energy, and, as is true in all cases of energy, is related to movement of particles. The moving particles involved in the production of ordinary heat are called molecules. Every known substance is composed of molecules, although there are many different kinds of molecules. A few molecules are large enough to be seen with the aid of powerful microscopes, but no single molecule has been seen with the unaided eye. For example, about 300,000 water molecules placed side by side would be approximately as long as this paper is thick.

Scientists believe that all molecules are vibrating even when they are collected in masses to form solids. The molecules of which this paper is composed are vibrating. If a cool paper is brought near a heated radiator, the individual molecules in the paper are thought to vibrate more rapidly, and the paper becomes warmer. The theory is that if a steel knitting needle is warmed, its molecules vibrate more rapidly; we say that the needle is becoming warmer. If this paper is put in a cool place, the molecules are thought to slow down in their vibratory movements, but to continue to vibrate. The speeding up and slowing down of vibrations of molecules is the scientist's explanation of heating and cooling.

Heat causes things to melt and to evaporate. The changing of a solid to a liquid is called melting; freezing is the opposite of melting. Although ice melts at 32° F., some materials melt at lower and others at higher temperatures. For example, tin melts at 449.6° F., zinc at 786.2° F., salt at 1490° F., copper at 1981.4° F., iron at 2786° F., platinum at 3092° F., and tungsten (the metal composing a light-bulb filament) at 6152° F. Mercury remains liquid until it is cooled to $-36.4°$ F., and alcohol remains liquid until it is cooled to $-457.6°$ F.

The changing of a liquid to a gas is called vaporization. Water will evaporate at room temperature, although it will evaporate more rapidly if it is heated. The boiling point of water at sea level and under normal atmospheric conditions is 212° F. When water boils

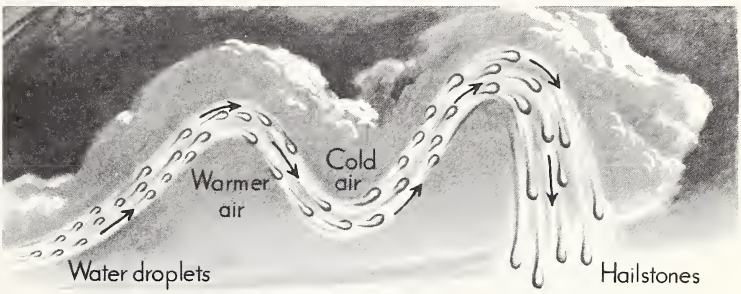
or when it evaporates at room temperature, liquid water changes to invisible water vapor. Water vapor is one of the several invisible gases composing the air. Steam is water in a gaseous state. The white cloud you see over a pan or kettle of boiling water is not steam; it is condensed water vapor. The steam, which is invisible, is between the cloud of condensed water vapor and the surface of the water in the pan or kettle. Steam is a gas, while condensed water vapor is composed of many droplets of liquid water.

Steam is invisible; it is the condensed water vapor that is visible.

Some materials, such as alcohol, gasoline, fingernail polish remover, and ether, evaporate more rapidly than water. Some scientists explain the evaporation process in the following manner. Whenever a substance evaporates, it does so because its molecules begin to vibrate so rapidly that they move off into the air. Heat causes this increased vibration of the molecules. The heat may come from a fire, from a warm surface, or from any other material warmer than the evaporating substance. When alcohol or water evaporates from the skin, the skin feels cooler because heat has been transferred from the skin to the molecules of alcohol or water. Since alcohol molecules can be set into faster motion more easily than water molecules, the skin loses heat to alcohol molecules rapidly. Thus the skin feels cooler when alcohol evaporates from it than when water evaporates from it.

Rain and dew are forms of condensed water vapor; they are droplets of liquid water. Frost forms when water vapor condenses on an object which is below 32° F. Snow forms when water condenses in the air at temperatures of 32° F. or below. Snow is really composed of small ice crystals, no two of which ever have been found to be exactly alike but each of which has six sides. Sleet is frozen rain or frozen partly-melted snowflakes.

Hailstones are frozen water. They begin as falling droplets of water. Falling into a layer of cold air, the droplets freeze. Then



Hailstones form as drops of water are alternately carried into cold and warmer areas by the upward currents of warmer air and downward currents of cooler air.

passing through warmer air, they gather moisture. Being lifted by rising warmer air, they again strike colder air and the added moisture freezes. This process may be repeated several times until the hailstones become so heavy that they drop to the ground.

It is thought that when anything is heated, the molecules of which that thing is composed begin to move more rapidly. If a liquid or a gas is heated, the molecules apparently move about more freely. We say that the liquid or the gas circulates.

When a solid, such as a silver spoon, is heated, the theory is that the molecules begin to vibrate more rapidly. Then we say the metal is hot. The molecules nearest the heat are set into more rapid vibration first. Finally all the molecules are vibrating so rapidly that we say the spoon is hot. Heat has been conducted through the spoon.

When gases or solids or liquids are heated, they expand. Scientists think that when molecules are in more rapid motion, they push each other aside more easily, and the material takes up more room. Thus, solids or liquids or gases which are being cooled contract as the molecular motion slows down. In most instances, materials contract more and more as they become cooler. However, water and a few

other substances expand slightly when they freeze. When water freezes, crystals of water are formed. The arrangement of these crystals, as they move into position, causes the water to expand slightly as it changes from a liquid to a solid.

Ways of Working with Children

The study of this chapter need not follow the first chapter, "Plants Are Protected," although the material presented there may be useful as questions arise concerning the rains, frosts, or early snows of autumn. The entire chapter or only portions of it can be used to help children answer some of their questions concerning heat phenomena.

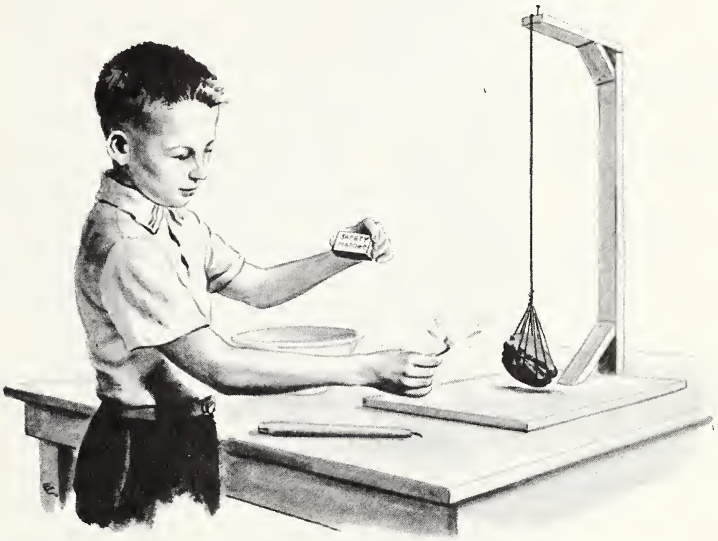
The experiences in this chapter may follow cooking experiences or camping experiences involving firebuilding. Or you may want to use the picture on pages 24 and 25 of *Adventuring in Science* to stimulate thinking concerning heat. This picture shows Parícutin, a newly-formed volcano in Mexico. Help children to understand that great pressure below the surface of the ground has caused rocks to melt. Because molten rocks take up more space than cooler rocks, they push other rocks and soil aside and may work their way up and out of the surface of the ground. Heat may cause a volcanic eruption.

The material in this chapter lends itself to much individual and group experimenting. A small linoleum- or oilcloth-covered table makes a good work surface for your experiments. You may want to do some of the experiments with the entire group. In other instances, a committee may work out an experiment and present it to the remainder of the group. Or you may prefer to have an individual perform the experiment. It is important to make time somewhere in your program for repetition of experiments either by the individual or by a small group. Many times the initial experiment needs to be repeated if the most is to be gained from it.

Children like to experiment. Let them work out the experiments on pages 26 and 27 of *Adventuring in Science*. A mere reading of such material is frustrating, to say the least. Take time to discuss the experiences involved so that you will have an opportunity to discover children's misconceptions concerning ice, water, and steam.

The evaporation experience, as well as the expansion and contraction experiences suggested on pages 28–33, involves action. Help

children use materials carefully and purposefully. For instance, when lighted candles are used, a pan of water should be available. Matches should be used with caution. A paper booklet of matches should never be permitted in the classroom. Instead, small boxes of matches should be used. When a match is struck, the box should be closed, and the striking motion should be away from the person handling the match.



You will want to emphasize the safe use of matches. A bowl of water should always be at hand as a precautionary measure.

The materials used in this chapter are easily obtainable by children from their homes. Both girls and boys are stimulated by learning through experiments. Repeat the experiences with the entire group, or allow children to repeat them in their free time.

Why things expand and contract is discussed on page 34 of *Adventuring in Science*. The ideas on this page require careful, unhurried thinking. Give children time to evolve ideas, give them time to present their new ideas to their classmates and you, give them time to use source material to check their ideas. This kind of discussion is the real meat of science experiences. If the "why" and "how" are omitted at this level of development, science experiences become tricks rather than rich, meaningful experiences. In the illustration on page 34, there are eighty red dots, twenty blue dots,

and one black dot in each balloon. Eighty red dots are used to indicate nitrogen molecules, since about 80 per cent of the molecules in the air are nitrogen. Since about 20 per cent of air molecules are oxygen molecules, twenty blue dots are used to represent these. The black dot represents carbon dioxide, since less than 1 per cent of the air molecules are carbon dioxide molecules. The second balloon is larger than the first, not because it contains more molecules, but because its molecules are in more rapid motion.

The thought-provoking experiences described on pages 35–37 of *Adventuring in Science* involve currents set up in liquids and gases because of unequal heating. More rapidly vibrating molecules are pushed upward as cooler, slower vibrating molecules sink to take their places. Pages 38 and 39 present ideas concerning conduction of heat in solids. Note that in this instance the vibrating molecules remain in a fairly limited area. They do not move from place to place as in the case of liquids and gases. Urge children to repeat these experiences at home and to look about them for as many examples as they can find of expansion due to heat. Discuss their ideas with them.

Pages 40–43 of *Adventuring in Science* present material which will be useful for reading to check ideas. Children may be led to theorize concerning the formation of frost or sleet or hail or rain or dew or snow. Then let them read for information. "What is freezing?" is a thought-provoking question. Lead children away from the idea that ice is the only frozen substance with which they are familiar. Iron, silver, gold, lead, dry ice, paraffin, and many other substances also are frozen.

Experimentation is an excellent means of learning, but you will want to help children form the habit of using reliable sources to check on their ideas and experiences.

Materials Needed

alcohol, rubbing
balloon
candle
cloth, dark
cork
cotton
dish, Pyrex

electric hot plate, Sterno stove, or other heating unit

food coloring or water-soluble paint or ink

glass

ice
ink bottle, with cork or screw top

jars, 2 same size

knitting needles, 3 steel

matches, small box
measuring cup
measuring tape
milkweed seeds, bits of tissue paper, or small feathers

newspaper

pail or deep glass dish
pan
paraffin or candle wax
plaster of Paris
plate
pot holder

saucer
sawdust, 2 tablespoons
shoe box
shoe trees, 4
spoons, 3 same size and of different materials
stone, weighing about $\frac{1}{2}$ pound
string

thermometer, Fahrenheit indoor or outdoor
thread

wall hook or stand for suspending object
wire, 2 feet, iron picture, or uninsulated copper

This Is for You

See suggestions for children, page 43, *Adventuring in Science.*

1. Heat may soften food, change its color and flavor, cause liquids to thicken, and kill disease organisms. Heat may cause food to burn and lose its vitamin content.

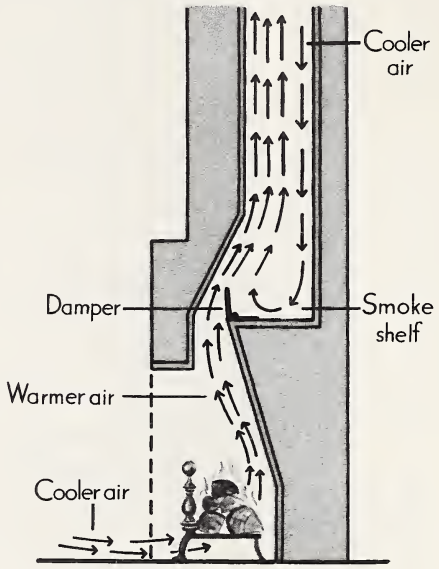
2. The concrete blocks expand when they are heated. If the blocks cannot expand horizontally, they will expand vertically.

3. Such an experience is more vivid than may be obtained by reading.

4. Cool air molecules enter the fireplace, stove, or furnace and push the warmer air molecules upward. These warmer air molecules carry bits of carbon from the fire upward with them.

5. Some substances conduct heat better than others. The following materials are listed in order with the best heat conductor

first and the poorest last: silver, copper, aluminum, iron, mercury, glass, water, wood, paraffin, alcohol, hair felt, air. Remember that a "tin" spoon is really an iron spoon coated with a thin layer of tin.



A good draft is necessary for a successful fire. Here cooler air replaces the warm air which is pushed up the chimney.

Further Activities

1. Encourage children to think of other experiments showing some interesting facts about heat. Try them out.

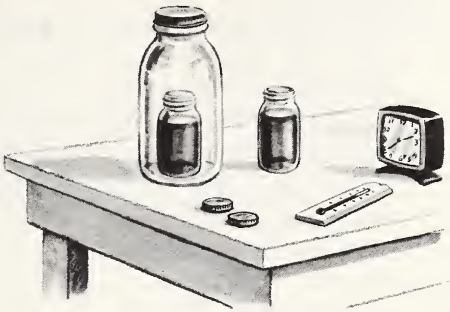
2. Discuss fire prevention rules.

3. Invite a person who has jewelry-making as a hobby to visit the classroom and demonstrate how he works with metals.

4. Help children to understand that winds are air disturbances resulting from unequal heating of the air. Air over dry places is warmer than air over moist places on a sunny day. The movement of cooler air toward warmer air creates a wind.

5. To help children understand more fully the principles involved in saving heat in our homes, let them try this experiment. You will need two small jars of the same size, a large jar with a cover, a thermometer, and hot water. Fill the two small jars with hot water and place one on a table. Place the second small jar in the large jar and put on the cover.

After a half hour, take the temperature of the water in each of the small jars. Repeat after another half hour. The water in the jar on the table will cool more rapidly than the water in the protected jar. Air surrounds the small jar within the larger jar. Since heat does not travel easily through still or noncirculating air, the water



in this jar cools less rapidly. Storm windows are put on houses to create an air space between two panes of glass, thus conserving heat.

6. Repeat this experiment, but put sawdust or some other good insulating material in the large jar. Then set the small jar of water inside it. Put insulating material around the sides and over the top of the small jar. This may help children to understand why we insulate our homes carefully to keep heat from passing out of the house in the winter and into the house in the summer.

Was It Worth While?

You and your children will want to raise this question from time to time during the study of heat energy, as well as at the end of the study. Perhaps the following suggestions will be useful in determining the progress of individuals in relation to these experiences.

1. Are your children handling materials with greater ease?
2. Do your children understand the purpose of the experiment in which they are engaged, or are they doing it as a trick?
3. Some children may want to make experiment books. Are they writing directions carefully? Are the experiment outcomes clearly stated?
4. Note whether or not your children are suggesting further ex-

periments and whether they are performing some of the experiments at home.

5. Let your children plan a program on heat for another group or for an assembly. Be sure that each child has a chance to contribute. You will be able to note individual progress in understanding of basic facts.

6. As the year progresses, assess the impressions these experiences have made on your children. Do they spontaneously follow rules of safety as they work with fire? Do they hold a jar under warm water when its metal cover is hard to remove? When the children are engaged in cooking experiences, do they remove metal spoons from pans; do they use pot holders; are they careful of steam? In other words, how well is newly-acquired information being put into action?

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Films

AIR ALL AROUND US. (YAF) 1 reel, b/w. Develops the ideas that air is real, can be weighed, expands when heated, and contracts when cooled.

MEASURING TEMPERATURE. (YAF) 1 reel, b/w. Shows that the liquid in a thermometer expands when heated and contracts when cooled.

PARÍCUTIN—MOUNTAIN OF FIRE. (Pictorial) 1 reel, color. Shows the development of North America's most recent volcano as it was photographed over a period of six months in Mexico.

SOLIDS, LIQUIDS, AND GASES. (YAF) 1 reel, b/w. Identifies common solids, liquids, and gases. Shows how a substance may change from one form to another.

THINGS EXPAND WHEN HEATED. (YAF) 1 reel, b/w. Uses animation to show that molecules are accelerated when heated. Points out that this acceleration in motion causes expansion.

WATER CYCLE. (EBF) 1 reel, b/w. Emphasizes the role played by heat in the evaporation and condensation of water. In addition, shows the circulation of water on the earth's surface and inside the earth.

WHAT MAKES RAIN? (YAF) 1 reel, b/w. Introduces the concept of the water cycle. Emphasizes evaporation and condensation of water.

Filmstrips

HOW HEAT IS TRANSFERRED. (YAF) color.

LIGHT. (YAF) color.

THE THERMOMETER. (YAF) b/w.

III

The Weather Today and Tomorrow

Observing and studying the weather is fascinating. How many of our activities are dependent upon weather conditions! We have formed the habit of listening to weather reports on radio or television each evening and morning. Children are aware of and interested in weather also, not only in the weather as such, but in the methods used in forecasting. This chapter presents some basic ideas concerning weather changes and forecasting. It is important for children to know that there is much about the atmosphere and weather conditions yet to be discovered. Man is learning new facts in this area continually.

Science Meanings for Children

Some of your children will have gained some of the meanings presented in this chapter through actual experience. It may be your goal to discover previous learnings, co-ordinate, and build upon them. In all cases, children's backgrounds in this area will vary.

The following meanings may help you to isolate individual understandings and enlarge, strengthen, and deepen them:

The weather changes from day to day.

Forecasting the weather depends upon a knowledge of air temperature, air pressure, air speed, air direction, sky condition, and cloud formations.

Air temperature is measured with a thermometer. The temperature of the outside air must be taken for weather forecasting.

Air pressure may be measured with a barometer. Air pressure may be taken either indoors or outdoors.

Wind is moving air. A wind is named for the direction from which it blows. Air speed is measured in terms of miles per hour.

Falling air pressure often indicates cloudier, stormier weather. Rising air pressure indicates fairer weather.

A study of weather records shows the changes which occur in the weather from day to day.

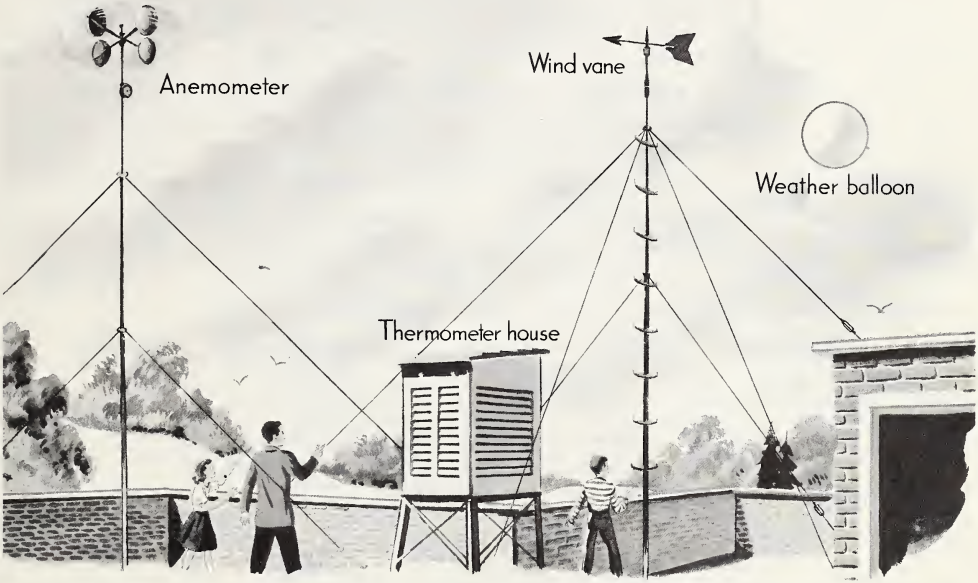
Different kinds of clouds have been recognized and given names. Clouds help us forecast the weather.

Some weather sayings are based on facts; others are not.

Workers at weather stations record and report useful information for us.

Information for You

Weather, which affects our lives greatly, is the sum total of changes in the atmosphere. A climate may change, but only over



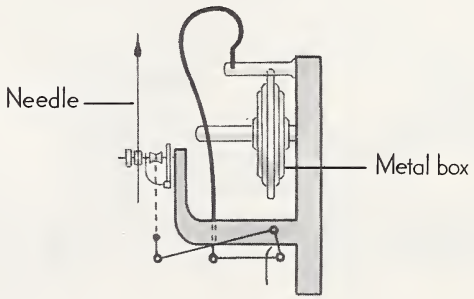
long periods of time. Seasons follow one another in regular succession, but weather changes from day to day or from hour to hour within the seasons. For instance, a temperate climate remains temperate with the same four seasons from year to year. But a temperate climate may have cold, hot, rainy, and dry weather during a season.

A weather forecaster is a trained weather observer. Forecasters note the air temperature, air pressure, wind direction and speed, sky condition, air humidity, and amount of precipitation. Children

ordinarily do not have available all of the instruments for the collection of these data, but they can learn a good deal about weather changes with instruments which are available to them.

The temperature of the air is measured out of doors with a thermometer. The thermometer should be shaded from the sun. Directions are given on page 48 of *Adventuring in Science* for setting up an outdoor thermometer station. The picture which appears on page 62 of *Adventuring in Science* and the similar labeled picture in the Manual show a thermometer house at an official weather station. The thermometer is inside the slatted house. The slatted sides allow free circulation of air, but the thermometer is shaded from the sun.

The speed of the wind is measured at weather stations by an anemometer. As the wind whirls the anemometer a gauge shows the wind speed. Wind direction is indicated by a wind vane or wind sock. The arrowhead of the wind vane points into the wind, while the wind sock flies with the wind. In this picture, a balloon has been released. Trained weather observers follow the progress of balloons such as this with special instruments in order to determine the wind speed and direction high above their point of observation.



This is a cross-sectional drawing of an aneroid barometer.

Air pressure may be measured with an aneroid barometer such as the one pictured on page 50 of *Adventuring in Science.* As indicated in the drawing above, there is a small, metal box inside the barometer case from which most of the air has been removed. When air pressure increases, the sides of this box are compressed, and the dial needle moves to the right. This is the direction indicating fairer weather. When air pressure decreases, the box expands slightly, and the dial needle moves to the left. This is the direction indicating stormier weather. Warm, moist air is lighter than cooler, drier air

A Cape Cod barometer is less accurate than either a mercurial or aneroid barometer.

because there are fewer air molecules in a given volume of the warm air.

The Cape Cod barometer shown here is useful, though less accurate than an aneroid barometer. Temperature changes cause the water in a Cape Cod barometer to expand and contract, thus affecting the level of the water in its spout. Such a barometer is more accurate if it is kept in a room having a fairly constant temperature. Air pressure also affects the level of the water in the spout of a Cape Cod barometer. Increasing air pressure causes the water to move downward in the spout. Decreasing air pressure allows the water to rise in the spout. Since increasing air pressure is associated with clearer weather, a "falling" Cape Cod barometer indicates such weather. And since decreasing air pressure indicates unsettled weather, a "rising" Cape Cod barometer indicates such weather.

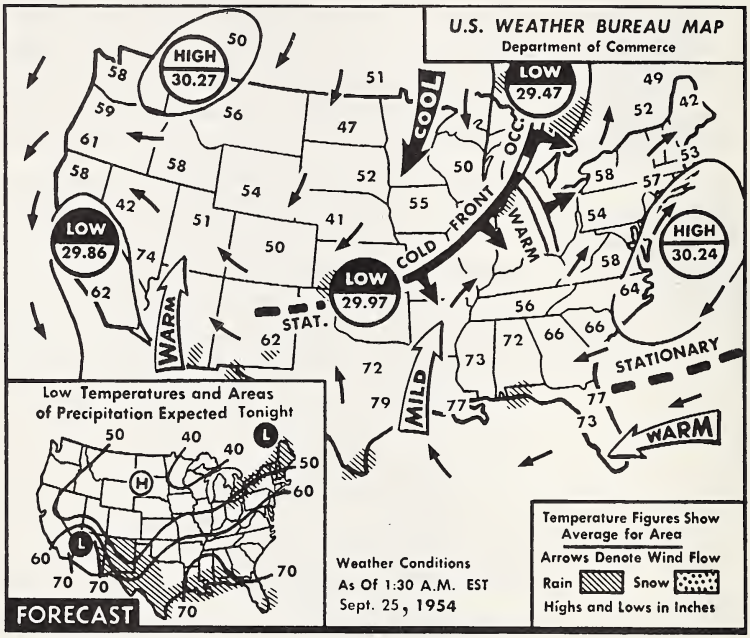
As your children keep weather records you may find that they will become interested in weather maps seen over television or in the local newspapers. You will want to recall that a good part of Canada and the United States lies in the region of prevailing westerly winds of the North Temperate Zone. Global wind movements in this area are from west to east. These winds cause areas of lighter, warmer air, known as low-pressure areas or "lows," to move across the North American continent from the Pacific to the Atlantic. These same prevailing westerlies cause heavier, cooler air, known as high-pressure areas or "highs," to move in the same direction. The heavier and cooler air from the surrounding country flows from all directions toward the low-pressure area. When this air reaches the low-pressure area, it moves upward. The water vapor in the air is cooled as the air moves upward and is condensed. Clouds are thus formed, and rain or snow or sleet or hail may fall.

Low-pressure areas are called cyclones, and high-pressure areas are called anticyclones. Cyclones and anticyclones, low- and high-pressure areas, do not remain long in one place in the region of prevailing westerlies. They move with the global wind current from west to east.

Storms are associated with low-pressure areas. This is because the air containing water vapor is moving upward into cooler regions. Therefore the water vapor may condense. The rapid upward movement of air in a thunderhead may cause charges of electricity to be built up. When the electricity is discharged, we see lightning.

Thunder occurs almost simultaneously with the lightning but is not heard until later, because sound travels only about 1100 feet per second whereas light travels about 186,000 miles per second.

Tornadoes and hurricanes are areas of extremely low air pressure. The typical, funnel-shaped cloud of a tornado is pictured on page 58 of *Adventuring in Science.*

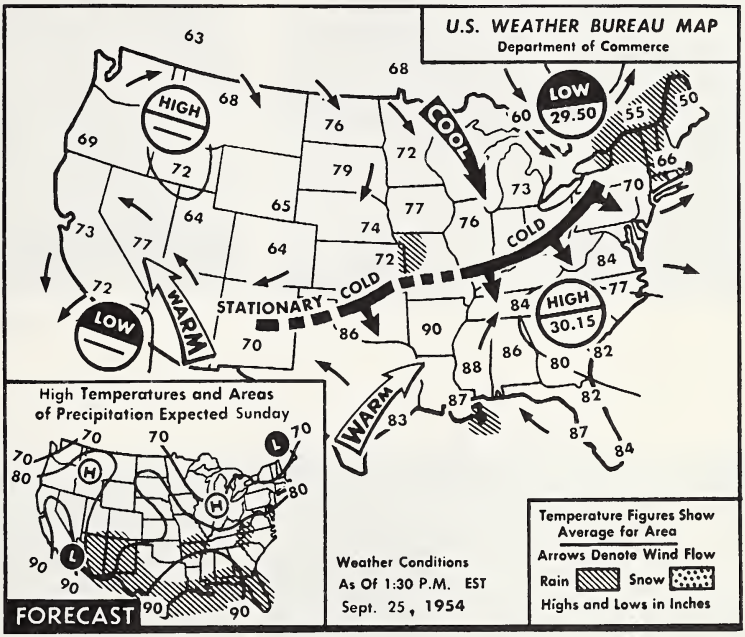


Wide World Photos, Inc.

In addition to the other clouds pictured and described on pages 56–58, you probably will want to know the names of four other important cloud formations. Cirro-stratus are very high, wispy, veil-like clouds which cause the sky to look whitish. They may cause halos of the sun or moon. Alto-cumulus clouds are similar to cirro-cumulus ones, except that the former are more grayish than white. The units of this cloud are small, thin, rather globe-shaped masses. Alto-stratus clouds form a gray-blue veil over the sun or moon, at times being so thick that they hide these bodies. Strato-cumulus clouds are somewhat like alto-cumulus clouds, except that the globe-

shaped masses are larger, somewhat thicker, and have darker parts. A chart showing excellent photographs of these clouds, entitled *Cloud Forms*, may be obtained from the Superintendent of Documents, Washington, D.C., for about ten cents. Cirrus, cirro-cumulus, and cirro-stratus clouds are usually 20,000 feet or more above the ground. Alto-cumulus and alto-stratus clouds usually are between

Note that the two weather maps show the changes in the weather after a twelve-hour interval. The movement in the general west-to-east direction of the cold front and of the highs and lows is indicated.



Wide World Photos, Inc.

6500 and 20,000 feet high. Strato-cumulus, stratus, and nimbo-stratus clouds are about 6500 feet or lower. Cumulus and cumulo-nimbus clouds form between 1600 and 20,000 feet above the ground.

Weather reports are sent from stations in the United States to Washington, D.C. In Canada the reports are sent to Toronto. These two centers exchange reports. Data are recorded on maps. These data include thermometer readings, barometer readings, wind speed, wind direction, type and amount of precipitation, and the like. Since the high-pressure and low-pressure areas in this region move in a generally west-to-east direction, study of these data

U. S. Weather Bureau, F. Ellerman

Cirrus

USWB, C. E. Depperman

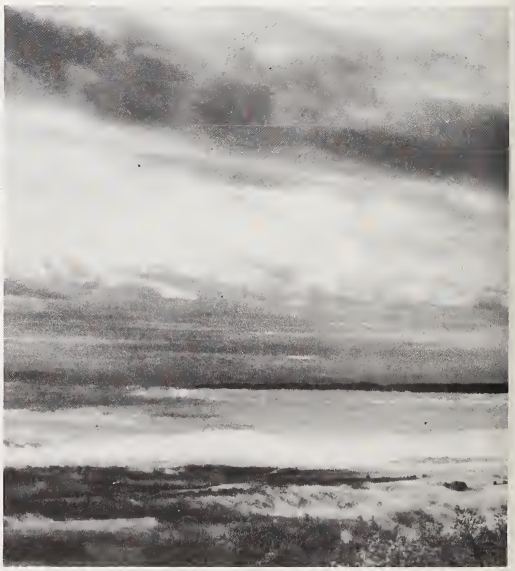
Cumulus

Cirro-cumulus

USWB, E. E. Barnard, Mt. Wilson, California

Stratus

USWB



USWB

Cirro-stratus

USWB, G. A. Lott

Alto-cumulus

Alto-stratus

USWB

Strato-cumulus

USWB, Anseo

helps in weather forecasting. The same general weather that is reported west of a place may be expected to arrive within a certain number of hours, according to the speed at which the pressure area is moving.

Weather reports are given out in newspapers and over radio and television. These reports are of value to such workers as builders, fishermen, farmers, gardeners, bakers, seamen, and truckers. A visit to your local weather station will prove interesting to you and the children.

Ways of Working with Children

This chapter may be used at any time during the year and is independent of other chapters in *Adventuring in Science.* However, you may wish to use it in conjunction with the second chapter, "Heat Causes Changes," since the sections on air movement and water vapor may make more concrete the study of weather changes. If you use the weather material early in the year, your children can continue to make observations and study the weather in connection with their daily activities throughout the year.

Unusual weather phenomena such as the first snowstorm or a heavy rainstorm or unseasonably warm weather may motivate the use of the material in this chapter. Or you may wish to arouse the curiosity of the children by studying the picture on pages 44 and 45 of *Adventuring in Science* and by asking the children what they know about the weather.

Help children strive for accuracy—accuracy in making charts or graphs, accuracy in reading instruments, accuracy in observation, and accuracy in recording. You will want to help children form the habit of asking others to aid them in checking their observations.

If an outdoor thermometer is available for your use, be sure that it is placed so that the sunlight will not strike it. Perhaps you will want to help your children build the thermometer station described on pages 47 and 48 of *Adventuring in Science.*

Children can set up a weather station in a corner of the room. Use the picture on pages 46 and 47 of *Adventuring in Science* for ideas concerning this weather station. Air pressure may be read from an aneroid barometer, or a Cape Cod barometer may be used to note whether air pressure is decreasing or increasing. If you cannot get such barometers, look in the newspaper or use radio or tele-

vision reports for barometer readings. These readings may be used in keeping records of air-pressure changes.

Wind speed may be estimated by using the chart on page 49 of *Adventuring in Science*. The information on this and the preceding page will help children determine wind direction.

The charts on pages 51–55 of *Adventuring in Science* are suggestive of those which might be kept by your children. Use your charts in attempting to forecast the weather. If you live in the region of prevailing westerlies, you will find that during the winter the low-pressure areas usually last about three days. These usually are followed by high-pressure areas which last also about three days.

If it is possible, study weather from time to time during the year. Record weather information at these times and keep the records. At the end of the year, study the weather records kept at various times in order to gain some understanding of the kinds of weather common to your region during the various seasons.

Observe cloud formations from the windows of your room, or better still, take the children outdoors to observe clouds on various days. If this study is continued over a period of time, children will begin to associate certain cloud formations with certain types of weather.

Help children to see that some of our weather sayings or proverbs were probably based upon accurate observation. Analyze weather proverbs with your children to determine their accuracy.

If it is at all possible, take your group to visit a weather station. Study the picture on page 62 of *Adventuring in Science* before you go. Make a list of questions to be asked of the workers at the weather station. Children will extend their understanding of weather a good deal by participating in a trip of this kind.

Finally, help your children to think of as many ways as they can that people make use of weather reports.

Materials Needed

barometer, aneroid or Cape Cod
board or post, 5 feet long
board, 2 feet square
hammer
nails
thermometer
wire, 3 feet

This Is for You

See suggestions for children, page 63, *Adventuring in Science.*

1. Often cooler weather makes us feel more peppy. If the humidity is high, we feel less peppy. Dogs, cats, and other animals seem to be affected by the weather also.

2. This will help children become more conscious of scientific information available to them.

3. Write to the Superintendent of Documents, Washington, D.C., for this chart entitled *Cloud Forms.* The cost is about ten cents.

4. The purpose of this experience is to encourage children to use resources available to them outside the classroom.

5. Again, attention is directed to valuable sources of information located outside the classroom.

Jane Coons

Seeing a rain gauge in operation stimulates further study of the weather and the instruments used in preparation of weather reports. This gauge is maintained at a small airport.

Further Activities

1. Collect a series of weather maps from the newspapers. Check the records with your own experimental records. Note how the high- and low-pressure areas move from west to east.

2. Use newspaper weather maps or radio and television reports to discover weather to the west of your community. How long does

it take the weather to reach you, if it does reach you? Do this upon several occasions.

3. Note the weather conditions in other cities on certain days. Help children understand something about the weather and climate of other places.

4. Let children photograph or paint cloud formations. Perhaps they will become more familiar with cloud formations in this way.

5. Help those children who wish to do so make weather booklets. Some children may make booklets concerning weather proverbs. Others may want to keep their own records concerning the weather. Still others may wish to make a booklet concerning cloud formations and their importance.

6. On various days, encourage children to note the kinds of clouds and the speeds at which they move. Encourage children to estimate how far they can see on certain days, using known distances to several landmarks to aid in this. Children can make these observations from their own classroom.

Was It Worth While?

This chapter gives a chance for much individual work as well as group work. Perhaps you can help children assess their abilities and understandings by suggesting that they ask themselves such questions as:

1. Have I improved in my ability to read a thermometer accurately? Do I know how to record the reading accurately?

2. Am I able to do the same for barometric, wind speed, and wind direction readings?

3. Am I more responsible in remembering to read the weather instruments and record the readings?

4. Am I willing to ask others to help me in making sure my observation was accurate?

5. Do I argue about differences in observation or do I try to find out why the difference occurred?

6. How would watching clouds tell me something about the atmosphere?

7. Have my ideas about the atmosphere changed? If so, how have they changed?

8. Do I make use of weather reports? How does the information in these reports influence the way I dress or plan for the day?

9. Have I found stories in the newspapers concerning weather conditions in other cities or countries? How have these weather conditions influenced people living in those places?

10. What are some unanswered questions about the atmosphere and weather conditions? Do I think man is finding new information about the atmosphere? Have I any evidence of this?

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Films

AIR ALL AROUND US. (See film list for Chapter 2.)

CLOUDS. (ALF) 1 reel, b/w. Shows various kinds of clouds, how they are formed, and the part they play in weather.

EVERYBODY TALKS ABOUT IT. (TFC) 1 reel, b/w. Depicts the work of the United States Weather Bureau.

MEASURING TEMPERATURE. (YAF) 1 reel, b/w. (See film list for Chapter 2.)

Orange Grower. (EBF) 1 reel, b/w. Shows how an orange grower and his family work through the year to produce high quality fruit. Effects of adverse weather conditions are shown.

Story of a Storm. (Cor) 1 reel, b/w & color. A dramatic story of the development and effects of a rainstorm. Names various kinds of clouds and shows weather instruments.

Summer on the Farm. Autumn on the Farm. Winter on the Farm. Spring on the Farm. (EBF) 1 reel each, color. Four films showing weather during the four temperate-zone seasons. Typical activities on a farm during these seasons are depicted.

Thunder and Lightning. (YAF) 1 reel, b/w. Presents the why and how of thunder and lightning as weather phenomena and as static electricity phenomena.

Water Cycle. (See film list for Chapter 2.)

Weather Wizards. (TFC) 1 reel, b/w. Shows how a modern weather forecasting station gathers information concerning the weather. Stresses the importance of weather forecasting to economic life.

What Makes Rain? (See film list for Chapter 2.)

Winds and Their Causes. (Cor) 1 reel, b/w & color. Discusses wind belts of the earth as well as local weather effects, such as thunderstorms.

Filmstrips

Clouds and Weather. (SVE) b/w.

Rain. (FH) b/w.

What Is Weather? (JH) color.

What Makes Rain? (YAF) b/w.

What Makes the Weather? (JH) color.

Why Does It Rain, Snow, Hail, and Sleet? (SVE) b/w.

Why Does the Weather Change? (SVE) b/w.

IV

Changes in the Sky

From time immemorial people have looked out into the sky and wondered about the bodies they saw there. Children of today wonder also. Their wonder and interest have been heightened by man's preparations for flights into space. Radio and television programs make use of this challenge to the imagination of children. You, too, will want to capitalize on this interest and curiosity of children concerning space and the bodies in space You will want to help children distinguish truth from fantasy in the comic books they read, in the radio programs they hear, and in the television and moving pictures they see and hear.

Science Meanings for Children

As you talk with children you will discover the ideas they have concerning bodies in the sky. They probably will know that the earth spins or rotates on its axis thus causing day and night, that the earth makes one complete revolution about the sun in $365\frac{1}{4}$ days, that the sun and earth are spheres, and that the sun is much larger than the earth but very far away.

Here are other science meanings which you may want to develop:

The moon is the regular sky body nearest the earth. The sun is much farther from the earth than the moon.

The moon is a sphere, smaller than the earth. The moon has mountains and valleys but no air, water, or living things. The moon reflects some of the sun's light; we call this reflected light moonlight.

The moon does not change in size or shape; it appears to do so because of conditions under which we see it. When the moon is directly between the earth and sun, the sun is eclipsed. When the earth is directly between the moon and sun, the moon is eclipsed.

Astronomers can predict when the phases of the moon, eclipses of the moon, and eclipses of the sun will occur.

In addition to the earth and its moon revolving about the sun,

other planets and their moons, planetoids, comets, and meteors revolve about the sun.

Each planet has days and years which are different from those on any other planet, but the reasons for all planets having days and years are the same.

Planets, including the earth, go through phases.

It might be possible, though uncomfortable, for a person from the earth to exist on Mars, but not on the other planets.

The planetoids are very small planets, barren of air, water, or life.

Meteors are bits of dust or stones which burn upon contact with the earth's atmosphere.

Many comets revolve about the sun, but few are seen with the unaided eye.

The sun is one of billions of stars in the sky.

"Up" is away from the earth's center; "down" is toward the earth's center.

Today we make use of instruments which give us quite accurate information about the bodies in the sky.

Information for You

The sun is one of billions of stars, each of which gives off light and heat. Because of our relative nearness to the sun, it is our greatest single source of light and heat. Many stars give off much more light and heat than the sun; some stars give off less light and heat. The sun seems to give off the most light and heat because it is so much nearer to us than are the other stars. The sun is only about 93 million miles from the earth; the next nearest star, Proxima Centauri, is more than 265,000 times as far away, or about 25 trillion miles away. All the other stars are out beyond this next nearest star.

Other bodies which we see in the sky are a part of our solar system, or sun's family. The earth, eight other planets, the planets' moons, the comets, and the meteors revolve about the sun.

The moon is our nearest regular sky neighbor and revolves about the earth. So far as we now know, no other body in the sky revolves about the earth. Often we speak of the moon as being a cold, dead body. Actually, it is both hot and cold. The part of the moon receiving light from the sun becomes exceedingly hot, probably 212° F., since there is no air to shield the moon's surface from the great heat of the sun. Since there is no air either to hold heat near

the moon's surface, the long lunar night is very cold with temperatures far below the freezing point of water.

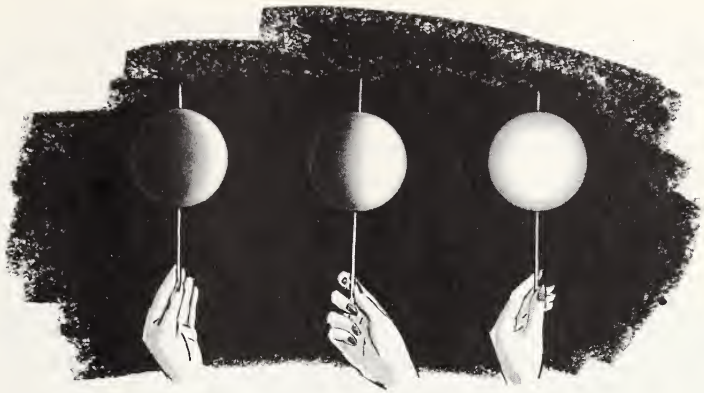
Moonlight is reflected sunlight. The moon is not a source of light; we see it as we see one another. The moon reflects the sun's light just as we reflect light to one another's eyes. Dust in our atmosphere acts as a screen in relation to the moon's light. When the moon is near the earth's horizon, it may appear to be more red or orange in

Lick Observatory Photograph

The plains on the moon are more barren than the rocky deserts of the earth, and the lunar mountains are more rugged than the peaks above the timber lines of the mountains on the earth.

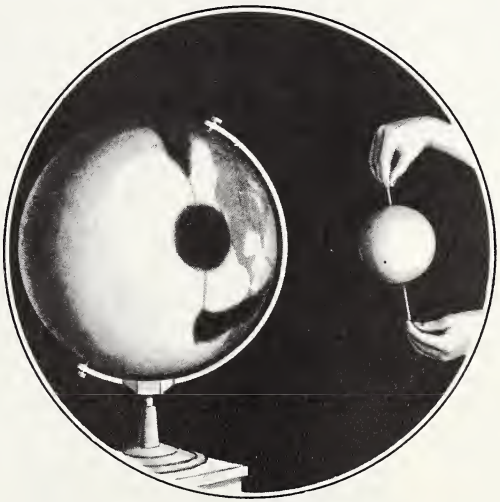
color than when it is higher in the sky. Dust bends the rays of light reflected from the moon, the blue light being bent more and the red and yellow light less. Consequently, more of the red and yellow light reaches our eyes.

It would be well for you to try out the experiment concerning the moon's phases described on pages 70–72 of *Adventuring in Science.* This will aid you in helping children understand why the moon goes through phases as it revolves about the earth in twenty-nine days. If you put a mark on the ball used in this experiment and keep the mark toward you at all times, you will see that each part of the moon receives light for approximately fourteen days and is in darkness for



These phases of the moon will be demonstrated on the tennis ball in the experiment described on page 71 of Adventuring in Science.

the same length of time. In other words, a moon day is about fourteen of our days and nights in length; a moon night also is about fourteen of our days and nights in length.



Using a tennis ball on a steel needle to represent the moon, a lamp to represent the sun, and the globe to represent the earth, this demonstration shows that when the moon's shadow falls on the earth an eclipse of the sun appears at that point.

Eclipses of the sun and moon do not occur each month because the moon's orbit is slightly tilted in relation to the earth's orbit. Thus the earth, moon, and sun are not often in a direct line.

Mercury and Venus are nearer the sun than the earth is, while the other planets are farther from the sun. Perhaps Chart 1, page 52, concerning the planets will be of some help to you. Certain data

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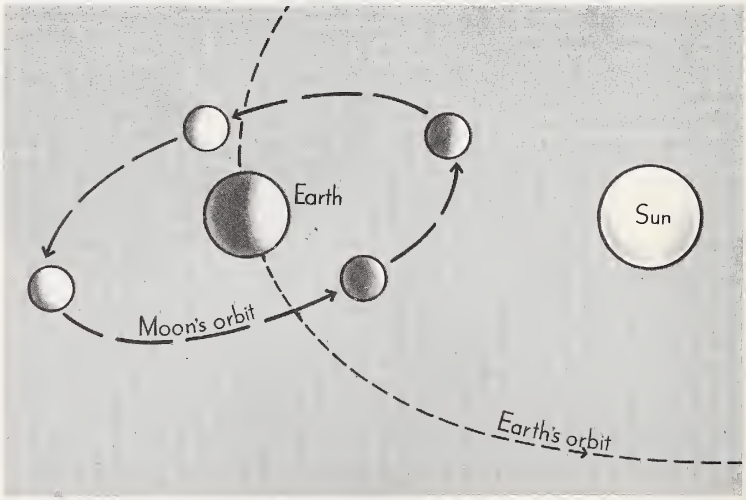
CHART 1 · THE PLANETS*

Planet	Distance to sun in millions of miles	Diameter in miles	Period of rotation (day and night)	Period of revolution (year)	Number of moons
MERCURY	36	3,100	88 days	88 days	0
VENUS	67	7,700	225 days (?)	225 days	0
EARTH	93	7,900	24 hours	365 days	1
MARS	142	4,200	24.5 hours	687 days	2
JUPITER	483	86,700	10 hours	12 years	12
SATURN	886	75,000	10.2 hours	29.5 years	9
URANUS	1,780	31,000	10.8 hours	84 years	5
NEPTUNE	2,790	33,000	15.8 hours	165 years	2
PLUTO	3,670	3,600	?	248 years	?

*This chart is presented only as background information which may be useful to you in helping children find answers to their questions concerning the planets. It is not intended that children should memorize these data.

for Pluto are missing because that planet is so distant that it is difficult to observe.

It is interesting to note that certain "facts" concerning the planets are constantly changing. During the preparation of *Adventuring in Science* it was necessary to change several of the figures for the diameters of the planets and their periods of rotation as new data were released by astronomical observatories. As instruments for viewing the sky are improved other new material concerning sky bodies will become available for inclusion in this study.



This diagram indicates the positions of the earth, moon, and sun during various phases of the moon. Because the moon's orbit is tilted in relation to the earth's orbit, an eclipse of the sun does not occur during each revolution of the moon about the earth.

So far as is known, no intelligent form of life exists on any planet other than the earth. There is a possibility that plant life exists on Mars, and perhaps on Venus. It is thought that Mercury would be far too hot on the side exposed to the sun's light and far too cold on the opposite side to support life. Jupiter, Saturn, Uranus, Neptune, and Pluto would be far too cold to support life as we know it. Jupiter's temperature is thought to be — 200° F., and the temperatures of the remaining planets are thought to be even lower.

This is one of the rare meteorites which reaches the earth's surface. It was found at Hoba West, near Grootfontein, Southwest Africa, and is estimated to weigh 60 tons.

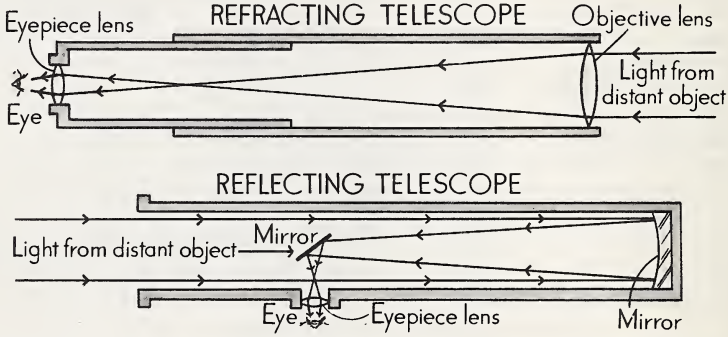
Photograph by Samuel G. Gordon, Expedition of The Academy of Natural Sciences of Philadelphia

Planetoids, or asteroids, are many in number, but all are small. The largest planetoid, Ceres, has a diameter of about 480 miles. Most of the planetoids revolve in orbits between those of Mars and Jupiter. However, the orbits of a few of the planetoids cross the orbit of Mars so that an occasional planetoid comes nearer to the earth than Mars.

Meteors, perhaps the remains of disintegrated comets, are constantly becoming a part of the earth. As they pass through our atmosphere most meteors burn completely, thus adding to the number of gas particles in our atmosphere. A few meteors are large enough to pass completely through the atmosphere and strike the land or water portions of the earth before they are entirely burned. The remains of meteors are known as meteorites.

Comets also follow regular orbits about the sun, although some of the orbits are much longer than others. Comets travel in a clockwise direction, traveling more slowly in the outer part of their orbits than when they are nearer the sun. The tails of comets are longer when they are nearer the sun, apparently owing to the fact that the sun's energy pushes the more tenuous gases out from the comet to form a tail.

Telescopes are of two general types: refracting and reflecting. Galileo's (1564–1642) telescope was a refracting one, which means that it contained two lenses, one at either end of the telescope tube. Newton (1642–1727) perfected the reflecting telescope. His telescope, although much smaller, worked on the same principle as does



the Hale telescope, described and pictured on page 94 of *Adventuring in Science*. Cameras are used in conjunction with telescopes. These cameras can be set so that they take pictures of the sky at regular intervals. Astronomers base many of their ideas concerning sky bodies on a thorough, careful study of these photographs.

Ways of Working with Children

It is not difficult to initiate a study of the bodies in the sky. This topic is one of the major concerns of children, judging from the amount of time they devote to thinking about and discussing the possibilities of space travel. Probably one of our major concerns in this regard should be to help children become better able to distinguish between fact and fancy.

Encourage children to tell what they know about space and the bodies in space. This is the time to air ideas; this is the time you

will note correct concepts and misconceptions. Lead children to see that their and our ideas are gathered from many sources. Help them to distinguish between reliable and unreliable sources.

Adventuring in Science may be used as one source. Children may wish to check the facts presented in this book against even more recent data available from astronomical observatories. Children should be encouraged to take imaginary trips to other bodies in the sky, but you will help them to base their journeys upon facts. Use the pictures on pages 64–66 of *Adventuring in Science* to help them visualize the moon and the way the earth may look as viewed from the moon.

Translate distances in space and the sizes of bodies in the sky into comparable smaller distances which can be experienced in the local community or on a globe or a map.

You will not overlook any experience which will help children concretize their ideas, such as the reflection experiment suggested on page 67 and the phases of the moon experiment on pages 70–72 of *Adventuring in Science*. Help children to use a source of light, such as a floor lamp, a globe, and a ping-pong ball on a steel knitting needle, to work out their explanation of eclipses of the sun and moon. Words can never give as complete a visualization as can actual experiences.

If it is possible, you will want to use a film such as *This Is the Moon* or *The Sun's Family* to clarify concepts regarding bodies in the solar system and their movements in relation to each other. Working through the experience described on pages 76–77 of *Adventuring in Science* may necessitate rearrangement of classroom furniture or use of the auditorium stage or gymnasium, but you will feel well rewarded for your effort when you see how children enjoy and profit by such an experience. This type of experience may stimulate the children in your group to suggest others related to the motion of bodies in the solar system. Whatever the experience, you will probably find it worth while to repeat it at least once.

Have fun with your children in planning a trip to Mars. What preparations would need to be made? Help them to think about provisions for food, water, oxygen, and heat. Their space ship would have to travel at least 27,000 miles an hour to escape from the force of the earth's gravity. The moons of Mars could be seen, but they would be very small. Phobos is about 10 miles in diameter, while the

diameter of Deimos is about 5 miles. To return to the earth, the space ship would need to travel at a speed of 11,160 miles an hour in order to escape from Mars. Less speed is necessary than for leaving the earth, since Mars' gravity, owing to its smaller size, is less than the earth's.

In addition to reading about and discussing the appearance and characteristics of the planets and planetoids, you will want to help children work out some concrete representation of the solar system, such as the one suggested on page 82 of *Adventuring in Science.*

In understanding why meteors burn, perhaps you will want to do some experiments with your children to help them understand that friction causes heat and sometimes light. In addition to rubbing hands together, pound a nail, use sandpaper on wood, rub a cloth briskly on wood, rub two sticks together, or strike a match. In each instance, heat will be produced by the friction. Study the pictures on page 85 in *Adventuring in Science.* Perhaps some of your children have seen a meteorite such as the one pictured at the top of the page. The Great Meteor Crater shown at the bottom of the page is almost a mile in diameter and nearly 600 feet deep. At one time it was probably deeper before rain washed soil into the crater. Perhaps you can help children understand how far a mile is by walking a mile, or thinking of a house or a building which is one mile away. Help children understand the 600-foot depth by comparing it with their school building. If each floor of the school building is 20 feet high, the crater would be as deep as a thirty-story building is tall.

Help the children gain a further understanding of space by using the picture which appears on page 84 of *Adventuring in Science.* Most meteors burn when they are within 100 miles of the earth's land and water. By this time, they have traveled through approximately 900 miles of the earth's atmosphere. Notice that the lighter blue at the top of the illustration indicates the thinning of the atmosphere at greater distances from the earth. The atmosphere 500 miles and 800 miles up is very thin indeed.

Children are not as familiar with comets as they are with meteors, but some children have heard or read about them and fear them. You can help children to understand that no one has ever been harmed by a comet, that these rare visitors apparently are made of very small stones and of gases. Halley's comet is due to return to the earth in 1985 or 1986. Children will enjoy determining their age

at that time and talking about what they might see when and if Halley's comet returns.

Have you ever thought of cutting out small cardboard figures and placing them on a globe in order to help children understand "up" and "down"? The illustration on page 88 of *Adventuring in Science* may help you to see how the figures might be placed. Talk with your children about trips they have taken, and ask them if they felt upside down. Place a figure on the globe where you live, then rotate the globe. This is what happens each twenty-four hours, yet no one feels upside down. Our bodies are accustomed to the earth's motion and its position in space, so we do not feel this motion.

You will want to take time to allow children to savor the beliefs of people who lived in past ages. Help them to see that the ideas of the ancients were not so strange for the times in which they lived. They had no instruments with which to view bodies in the sky. Therefore, their facts were more limited than ours. Each year new facts about the sky are discovered. Each year facts which we once believed to be true are revised. One of the most important concepts that you will want to develop in your teaching is this: *Changes occur constantly.*

Materials Needed

- bridge lamp or similar source of light
- clay or other modeling material
- flashlight
- globe of the earth
- knitting needles, 3 steel
- map of North America
- mirror, pocket
- ping-pong balls, 2
- tennis ball

This Is for You

See suggestions for children, page 95, *Adventuring in Science.*

1. Working out ideas in this way helps to make them more concrete and vivid.

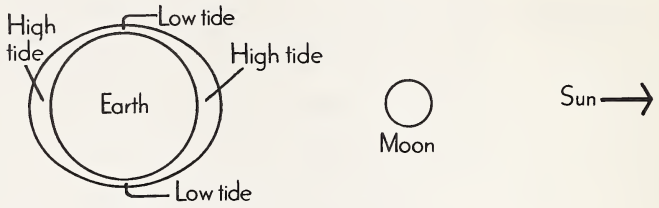
2. Sometimes an amateur astronomer is available in the community. If so, try using him as a resource person.

3. With field glasses, the mountains on the moon may be distinguished.

4. The earth is not a source of light and heat. It receives light and heat from the distant sun. Although the sun gives off a tre-

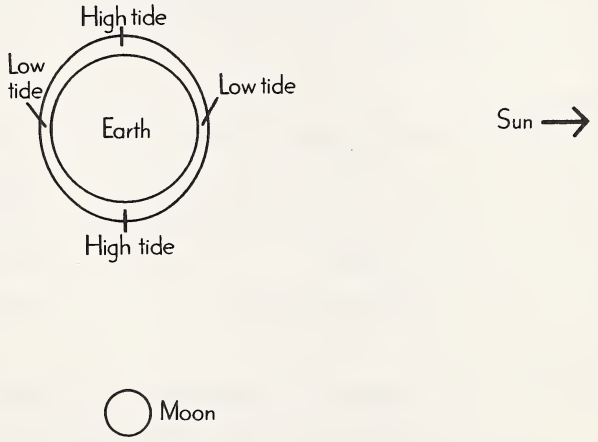
mendous amount of light and heat, the earth receives only about $\frac{1}{2{,}000{,}000{,}000}$ of the total. This is because the earth is so small in comparison with the sun that it intercepts a very small amount of the sun's total light and heat.

Spring tides occur when the tidal forces of the new or full moon and the sun act in the same direction. They are characterized by a large range between the depths of high and low tides.



5. About three-fifths of the tide-producing power on the earth is exerted by the moon and about two-fifths by the sun. Even though the sun is larger than the moon, it is so much farther away that its tide-producing power on the earth is less. The highest of the high

Neap tides occur when the tidal forces of the moon in the first or last quarter and the sun oppose each other. They are characterized by a small range between the depths of high and low tides.



tides, or spring tides, occur approximately twice each month at new moon and at full moon. At these times, the sun, moon, and earth are almost in a straight line. When the moon, earth, and sun are at right angles, tides are not very high. These tides occur at first and third quarters of the moon and are known as neap tides.

6. No green plants would grow without light for the food-making

process. Since all nongreen plants and all animals are dependent upon green plants for food, all life probably would become extinct. The earth would become very, very cold. There would be no moonlight or planet light. Light would come only from distant stars.

Further Activities

1. Draw a circle outdoors with a diameter of 54 inches. This represents the sun. Draw another circle $\frac{1}{2}$ inch in diameter at a distance of about 485 feet. This shows the proper relationship between the sun and the earth, both as to size and distance.

2. Help children visualize the size of our solar system in relation to the distance to the next nearest star. These are the facts: The distance from the sun to Pluto is about 4,000,000,000 miles; the distance from the sun to the next nearest star, Proxima Centauri, is about 25,000,000,000,000 miles. These distances may be reduced to a smaller scale. A golf ball will represent the sun. The earth is represented by a grain of sand placed 12 feet from the golf ball. Pluto is represented by a grain of sand placed at a distance of 500 feet from the golf ball. Proxima Centauri is represented by a second golf ball placed 600 miles away!

3. Try to discover if someone in your community has a small meteorite. Examine it carefully with your group and talk about its journey from outer space.

4. Read legends about the sun, moon, and planets. Try to think why ancient people believed these legends to be facts.

5. Obtain a calendar on which are indicated the times of the phases of the moon. Encourage several children to check each night for a month to see whether the calendar was correct in its predictions.

6. Watch the newspapers for announcements concerning eclipses, discoveries of new comets, and other such items. Suggest that these items be put into a class scrapbook. At the end of the year, summarize the astronomical happenings you have noted.

7. Try an evening field trip. Invite your group to return to the school grounds with their parents after dark. Choose an evening when the moon will not be above the horizon so that the stars and planets will be visible. Point out various interesting stars and planets to your group. If you feel unsure of yourself in this respect, invite someone in the community who knows more about sky bodies to be the guest of the evening.

Was It Worth While?

One of the most rewarding phases of teaching is being able to observe children as they form new and more carefully tested opinions. Ask children to write or tell about "Some of my beliefs about the moon (or any other sky body) that have changed." Then you might try to obtain information as to why they changed their beliefs. Such material as this gives you a good basis for appraising the growth of individuals, that individual growth with which we are so greatly concerned. It is unnecessary for a child to remember all the facts he has encountered in this study in order to grow in the ability to form new and carefully tested opinions. Each child will grow at a different rate in this respect, and the growth of each will be based upon a different set of facts which *he* has appraised and assimilated.

Children are rewarded in their realization of their own growth. If you and the children have the richly rewarding experience of knowing that a better basis for opinion-formation has been achieved, you will indeed have enjoyed a worth-while experience.

You will want to watch for other changes also. Are children better able to express their ideas concerning space? Do they use their imaginations in creating ways to communicate their ideas in this area? Are children who were fearful concerning the universe using information to eliminate these fears?

Do your children realize that man's ideas concerning the universe have changed? Are they conscious of their own developing concepts? Do they seek information willingly in order to clarify their concepts? Help children to use authentic information constantly in appraising their own ideas of space.

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Films

EXPLORING THE UNIVERSE. (EBF) 1 reel, b/w. Shows and discusses reflecting and refracting telescopes. Presents the sun as one of billions of stars, and depicts relationships among the stars.

LIGHT AND SHADOW. (YAF) 1 reel, b/w. Presents an introduction to the nature and behavior of light. Shows how light is reflected, and discusses luminous, transparent, translucent, and opaque objects.

THE MOON. (EBF) 1 reel, b/w. Depicts the phases of the moon and the reason for these phases. Deals with solar and lunar eclipses and their causes.

THE SOLAR SYSTEM. (Cor) 1 reel, b/w & color. Shows differences between stars and planets. Names the planets and discusses their relationships.

THE SUN'S FAMILY. (YAF) 1 reel, b/w. Gives an explanation of the solar system. Describes the planets as members of the solar system.

THIS IS THE MOON. (YAF) 1 reel, b/w. Discusses earth-moon relationships, reflection of light by the moon, and the moon's phases.

WHAT MAKES DAY AND NIGHT? (YAF) 1 reel, b/w. Depicts the cause of day and night as a result of the earth's rotation.

Filmstrips

Comets and Meteors. (SVE) b/w.
Constellations. (SVE) b/w.
The Earth in Space. (SVE) b/w.
How We Learn about the Sky. (JH) b/w.
Interesting Things about the Planets. (JH) b/w.
The Moon. (YAF) color.
A Multitude of Suns. (JH) b/w.
The Solar System. (YAF) color.
Stars and Galaxies. (SVE) b/w.
The Stars in the Sky. (EGF) color.
The Sun and Its Planets. (SVE) b/w.
What Is the Sky? (Curr F) color.

V

Plants and Animals Now and Then

Your community changes from season to season and year to year, although many of the changes are not always noticeable. If you have lived in your community since childhood, you will remember that certain buildings have been replaced, that new roads have been built, that former forest land is now farmed, or former farms have been abandoned. Perhaps the school in which you teach or the house in which you live is built upon land which was once a farm. Exploring the past can be an intriguing experience. The chapter "Plants and Animals Now and Then" presents material which may help children explore in time.

Science Meanings for Children

Children's time concepts are enlarging constantly. You are aware that their concepts differ from yours when they indicate how long it seems to them until Christmas or a birthday. As you lead your group in exploring the past you are helping them gain information which will make time more real. Dates are not so important, but time relationships are.

Perhaps the following are some of the meanings which your group will gain as they begin to explore the present and the past:

Some plants and animals live in many places, others live only in certain places.

There are many, many different kinds of plants and animals living on the earth.

Our community has not always looked as it does now. Some of the ancient plants and animals are now extinct.

Ancient plants and animals left traces of their life upon the earth; these traces are called fossils. No one knows why certain living things became extinct.

The kinds of rocks and fossils found in a community tell something of the history of that community.

The earth is very, very old.

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Key to Plants and Animals Shown in Illustration

1 hemlock	18 polar bear	35 palmetto
2 birch	19 Arctic tern	36 alligator
3 tamarack	20 husky	37 palm tree
4 maple	21 brown bear	38 coconut palm
5 moose	22 black spruce	39 macaw
6 cod	23 spruce	40 fern tree
7 blue crab	24 seal	41 boa constrictor
8 cow	25 eagle	42 anteater
9 corn	26 white spruce	43 banana tree
10 sheep	27 salmon	44 hummingbird
11 horse	28 gull	45 donkey
12 Douglas fir	29 crab	46 dolphin
13 prickly-pear cactus	30 marlin	47 whale
14 wheat	31 saguaro	48 tuna
15 mountain goat	32 rattlesnake	49 toucan
16 blue spruce	33 pig	50 monkey
17 wolf	34 dog	51 rubber tree
52 yucca		53 zebu (Brahman)

Information for You

Plants and animals live all over the earth—in the water, and on the land. Some of these living things are adapted to one type of climate, while others may be found existing in various climates. The smallest plants and animals cannot be seen unless a microscope is used. Some of these smallest of living things are made of only one cell, but the plants and animals with which we are most familiar are made of many cells.

CHART 2 · THE EARTH'S HISTORY*

Millions of Years Ago	Plant and Animal Life
PRESENT	One-celled plants and animals, shelled animals, worms, spiders, insects, amphibians, fish, reptiles, birds, mammals, fungi, mosses, ferns, conifers, flowering plants. Ancient mammals, such as mastodons and giant sloths, have become extinct.
60 MILLION YEARS AGO	All of the living things of 200 million years ago except for some forms of life, such as dinosaurs and toothed birds, which had become extinct. Mammals, birds, and flowering plants developed greatly during this time.
200 MILLION YEARS AGO	One-celled plants, sea plants, fungi, cycads, tree ferns, rushes, conifers, and, toward the end of this time, flowering plants. One-celled animals, corals, shelled sea animals, fresh and salt water fish, scorpions and spiders, insects, amphibians, reptiles, including dinosaurs, which developed greatly at this time, toothed birds, the first mammals.
500 MILLION YEARS AGO	One-celled plants, multicellular sea plants, first land plants, rushes, cycads, conifers, true ferns. One-celled animals, shelled sea animals, sponges, corals, scorpions (first air breather), fish (some with bony coverings and numerous sharp teeth), amphibians (some of which grew to be quite large), and insects (including 4-inch cockroaches and dragonflies with a 29-inch wingspread).
2000 MILLION YEARS AGO	One-celled plants and animals in the warm seas and oceans; toward the end of this time, multicellular sea plants, such as algae; and multicellular sea animals, such as sponges and worms.
2500–3500 MILLION YEARS AGO	The earth was formed. There were no living things on the earth.

*It is not intended that this chart be "taught." Children should not be required to memorize this material. The chart is presented only as background information which may be useful to you as you help children find answers to their questions concerning the history of plants and animals on the earth.

Probably the first living thing on the earth was a one-celled plant, living in warm sea water. After many, many years, multicellular plants probably developed. Then came one-celled animals and later multicellular animals. No one knows just when these forms of life developed, but present-day scientists suggest the time chart of the earth to be somewhat as outlined in Chart 2. You will note that only a few of the forms of plants and animals that existed have been mentioned in each period of time.

Of course, no one knows whether the history shown in the above chart is true, but scientists have tried to give us as true a story as possible by studying fossils and rock formations. They have attempted to ascertain the age of fossils and of rocks by determining the kind and amount of radioactive materials in the rocks. The amount of one type of radioactive material in relation to other kinds gives them a clue as to how long the rock has existed.

It is thought that dinosaurs (dī'nō sôr) appeared about 200 million years ago. The first dinosaurs hardly deserve their name, which comes from the Greek words *deinos sauros* (dī nôs sû ros) and means "terrible lizard," for they were only a foot or so in height. During the next 150 million years these animals developed tremendously. Some, such as *Brontosaurus* (brŏn tō sô'rŭs) and *Stegosaurus* (stĕg-ō sô'rŭs) shown on pages 100–101 of *Adventuring in Science*, walked about on four legs, lived in swamps, and ate plants. *Brontosaurus* weighed about 30 tons and was about 70 feet in length. Remains of this reptile have been found at Medicine Bow, Wyoming, and at the Dinosaur National Park near Vernal, Utah. *Stegosaurus*, or "roofed lizard," weighed about 10 tons and grew to some 25 feet in length.

Ornithomimus (ôr nĭ thō mī'mŭs), one of the last of the dinosaurs, walked about on its hind legs. This reptile was about 6 feet tall and seems to have lived on shelled water animals even though it had no teeth. *Tyrannosaurus rex* (tĭ răn ō sô'rŭs rĕx), also one of the last of the dinosaurs, was about 50 feet long and when standing was about 20 feet in height. This fierce, meat-eating dinosaur had rows of 6-inch long, daggerlike teeth in its mouth. These dinosaurs are shown on pages 100–101 of *Adventuring in Science.*

The dinosaurs shown on page 103 of *Adventuring in Science* also were among the last of these large reptiles. They are *Trachodons* (trā'kō dŏn), or duck-billed dinosaurs. These swamp-dwelling, plant-eating reptiles were about 35 feet long and were one of the most

common of all the dinosaurs. Many of their skeletons are found in Montana, Wyoming, and South Dakota.

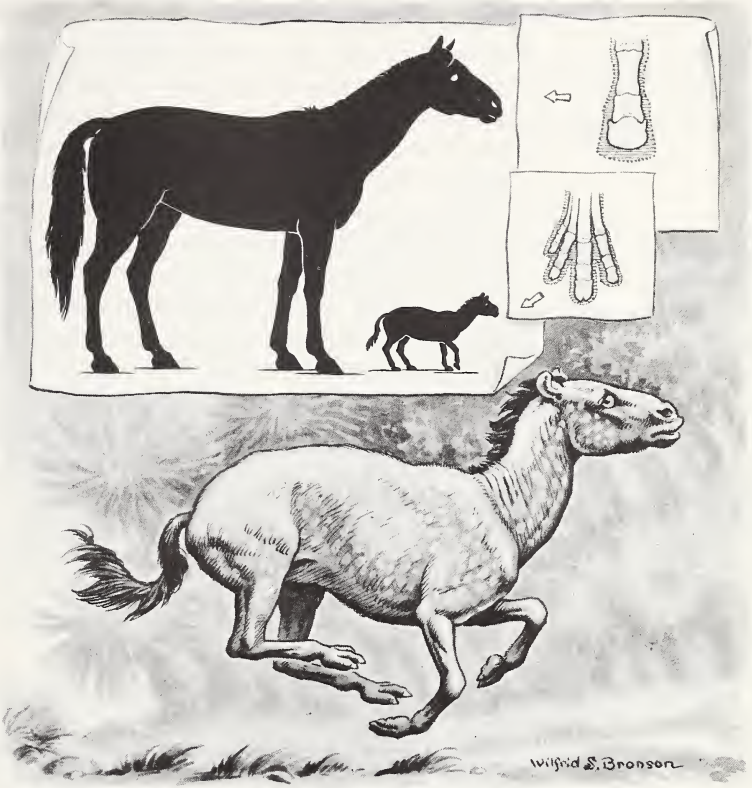
Two other interesting types of dinosaurs are shown on page 102 of *Adventuring in Science.* The flying reptiles, or pterosaurs (tĕr′ō-sôr), had skinlike wings, no feathers, and long mouths with many

The dinosaurs shown here are: Brontosaurus (upper left and right), Stegosaurus (lower left), and Triceratops (lower right).

teeth. Sometimes these ancient reptiles are called pterodactyls (tĕr-ō dăk′tĭl), or "feather fingers," since there were claws on their wings. Some of the flying dinosaurs were no larger than ordinary crows, but others had a wingspread of some 30 feet. Swimming dinosaurs, such as the plesiosaurs (plē′sĭ ō sôr) shown on page 102, had very long necks, small heads, and four paddlelike limbs. Some were about 50 feet in length. Other swimming dinosaurs, such as the ichthyo-

saurs (ĭk'thĕ ŏ sôr), or "fishlike reptiles," had fish-shaped bodies, porpoiselike mouths, and sometimes grew to be as long as 25 feet.

No one knows why these ancient reptiles became extinct. Some scientists suggest that the rapid development of flowering trees caused a change in diet which these animals could not survive.



A comparison is shown of the feet, ears, and size of the dawn horse and its modern descendant.

Other scientists suggest that rapidly developing small mammals preyed upon their eggs and young, or that they could not survive the more arid climate of some 60 million years ago.

During the last 60 million years, birds and mammals have developed rapidly. Early mammals were small. The horses and camels of this period were about the size of fox terriers. Mastodons, such as those shown on page 105 of *Adventuring in Science*, and

mammoths roamed over the land. The chief difference between these two mammals was in the shape of the molar teeth and in the fact that the mammoths had long, curving tusks. These mammals were well adapted to the glacial ages in which they lived, for they had heavy, woolly coats of hair. Again, no one knows just why these animals became extinct. Perhaps it was due to climatic change, some fatal disease, or attacks by their enemies.

Scientists gain information concerning ancient plants and animals from their remains in stones. These remains, or fossils, may be prints or casts of animals or plants. Sometimes entire animals were entrapped and preserved. Insects were trapped in the sticky sap of conifers. Some mammoths and mastodons became entrapped in the crevasses of glaciers, were covered with ice, and preserved. Fossils are now found in sedimentary rocks, since the sediments forming these rocks were deposited under water and have never been subjected to such tremendous pressures that the fossils have been crushed beyond recognition. The kinds of rocks which may be found in your region tell something of the history of the land there. Perhaps Chart 3 will help you in reading this history.

If you need more specific information about the rocks or geologic history of your community, it might be well to write to the department of geology of your nearest university or to a museum near you asking for pamphlets on these subjects. Or, better still, you may be able to talk with someone in your community who has considerable information concerning its geologic history.

Ways of Working with Children

The information in the chapter "Plants and Animals Now and Then" may be used as the need arises, since it is independent of all other chapters in *Adventuring in Science*. Perhaps you will want to arouse interest in the history of your community by asking such questions as "Do you suppose the kinds of animals which live here now have lived here always?" or "Do you think any animals ever lived on this continent which no longer live here?" Perhaps you will want to use the picture on pages 96–97 of *Adventuring in Science* as a starting point. This is the same picture that is reproduced on pages 72–73 of this Manual. The names of the animals and plants are given here to help you and your group identify the living things shown. Undoubtedly, the children will want to add

CHART 3 · COMMON ROCKS*

Common Sedimentary Rocks

Sediment	*becomes*	Sedimentary Rock	Where Formed
Lime (shells and bones)	⟶	Limestone (including chalk and coquina)	Sea or ocean
Sand	⟶	Sandstone	Shallow water (salt or fresh)
Mud	⟶	Shale	Swamp or lake
Pebbles, shells	⟶	Conglomerate	Fairly shallow water (salt or fresh)
Salt	⟶	Salt	Sea
Plants, peat	⟶	Bituminous coal	Swamp

Common Igneous Rocks

These rocks have been subjected to so much pressure and heat that they have melted and then cooled.

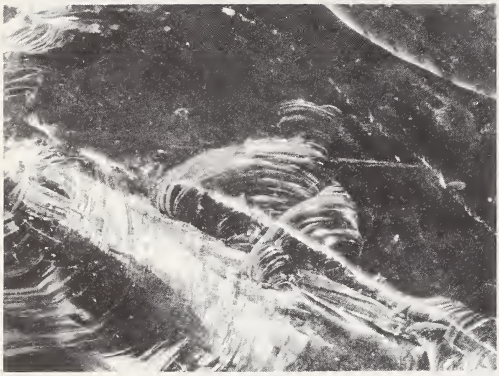
Kind of Rock	Where Cooled
Lava, pumice, obsidian	On surface of earth
Basalt	Near surface of earth
Granite	Deep within earth (30–50 miles)

Common Metamorphic Rocks

These rocks have been subjected to great pressure but not enough heat to melt them.

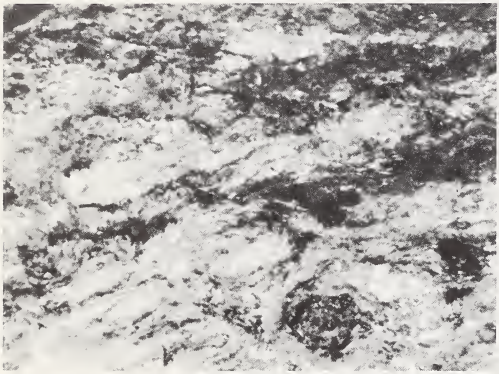
Original Rock	*becomes*	Metamorphic Rock
Limestone	⟶	Marble
Sandstone	⟶	Quartzite
Shale	⟶	Slate, mica schist
Conglomerate	⟶	Gneiss, conglomerate schist
Bituminous coal	⟶	Anthracite coal
Basalt	⟶	Slate, schist, serpentine
Granite	⟶	Granite gneiss

*This chart is presented as background information which may be useful to you in helping children find answers to their questions concerning the history of rocks. Children should not be required to memorize this material.

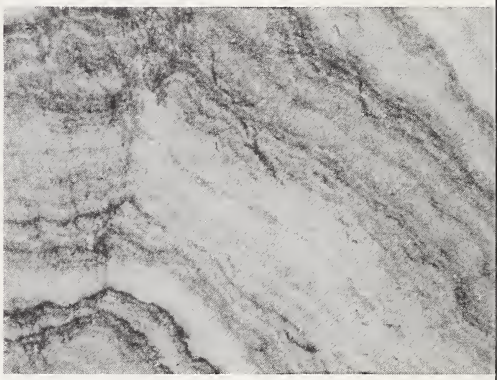


Obsidian

Conglomerate



Mica schist



Banded limestone

Fossiliferous limestone

Note the traces of fossil shells in the fossiliferous limestone rock at the left.

Photographs by Ward's Natural Science Establishment, Inc.

the names of many more plants and animals living in North, South, and Central America, as well as in other parts of the world.

Perhaps you will choose to make a list of all the plants and animals in your community which your group can name. Then you may wish to make such a list for a community with a very different climate.

After such a study, it may be interesting to begin making a list of plants and animals which no longer live in the community. The map of South Dakota on page 99 of *Adventuring in Science* gives an indication of an interesting way to report this information. Very probably you will find that dinosaurs once roamed over the place where you now live. Help children to satisfy their curiosity about these ancient animals. You will help them know that some were large and others were small, that some ate meat and others ate plants, but that all lived many, many years ago, and that all are extinct. Again, the geology section of your local museum or university will help you with facts concerning ancient life in your community.

The information on pages 65–67 of the Manual includes the names of the dinosaurs shown on pages 100–103 of *Adventuring in Science* and relates some additional interesting facts concerning them. Use this, as well as other information which you and your children will discover, to make explorations into the past more meaningful. Chart 2 on page 69 of the Manual may help you construct a time line which will aid children in placing the events of the past.

Try to read the story of your own community. If it is possible, visit a quarry with your children. Arrange for the trip so that one of the workers will act as your guide. Make work with "Plants and Animals Now and Then" a "doing" as well as a "reading and thinking" experience. Use the resources available among the people in your community to help you and your children with this study.

Materials Needed

fossils from your community, if any available

hatbox, oval, or a carton

modeling clay

sticks, 2 round, such as broomsticks, 24 inches long

stones from your community

Thinking about Your Community

See suggestions for children, page 108–109, *Adventuring in Science.*

1. If you feel unsure about identifying stones or fossils, ask the help of a person in your community. A number of people make collecting stones their hobby and will be glad to help you and your children, provided reasonable demands are made upon their time.

2. Such an experience as this helps children view their community with new eyes.

3. A ladies' oval hatbox makes an effective setting for the diorama.

4. Lead children constantly toward the concept that changes occur ceaselessly.

Further Activities

1. Make mud prints of shells or hands to help children understand how prints have been preserved. Fill a pie tin with fairly stiff mud and press a hand or a shell into it. Set this aside until it becomes dry. Examine the print.

2. Plaster of Paris prints may also be made. Add cold water to a cup of plaster of Paris until it is the consistency of thick soup. Drop spoonfuls on cardboard. Allow children to press into it their hand, a shell, or a leaf, each of which has been coated with vaseline. Let a hand remain only until the plaster of Paris begins to harden. The shells or leaves may be left in the plaster for an hour or two and then removed.

3. Visit a museum to study the geologic section.

4. Make a time line on a strip of paper fastened on the walls of your room above the blackboards and bulletin boards. Record major events in the development of plant and animal life on this time line.

5. Use your bulletin board to present children's drawings and magazine pictures showing ancient life on the earth. Two sources of such pictures would be the issues of *Life* magazine for September 7, 1953, and October 19, 1953. Help children select and arrange the pictures so that they tell a meaningful story.

6. Make a record of the ancient history of your community. This might be organized in the form of a class book.

Was It Worth While?

Again, you will want to evaluate in relation to individual growth. To do this you may want to jot down notes concerning the time concepts of individuals at the beginning of this study. Toward the end of the study, have a "What Do You Think of This Idea?" discussion. Read a child's original idea and ask him what he now thinks. Children should be a part of evaluation. Unless they learn the value of this early, they often look upon evaluation procedures as hurdles to overcome or by-pass rather than as procedures which may help them in their growth.

Perhaps your group will be preparing individual written or oral reports on plants and animals related to this chapter but not described in the chapter. How has the child progressed in his ability to organize information? Has he improved in his ability to make his ideas clear to others?

The material in "Plants and Animals Now and Then" lends itself well to organizing into a program for presentation to another group. In planning the program, notice how well the children are able to work with others. Does each child take his share of the load?

It is not important for children to learn the names of the plants, animals, or stones presented in this chapter. But it is important that their general concept of time be expanded and strengthened. It is important that situations be created in which they may work responsibly and co-operatively.

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Films

BEACH AND SEA ANIMALS. (EBF) 1 reel, b/w. Presents the activities of the starfish, sea urchin, crab, cuttlefish, octopus, crayfish, lobster, shrimp, snail, scallop, and sea cucumber. Emphasizes the interrelationships among animals and their environments.

COMMON ANIMALS OF THE WOODS. (EBF) 1 reel, b/w. Studies a squirrel, rabbit, raccoon, porcupine, otter, mink, beaver, opossum, skunk, and woodchuck, each in its natural habitat.

FARM ANIMALS. (EBF) 1 reel, b/w. Kinds of animals found in a typical farm community are shown. Tells how they are cared for and their uses to the farmer.

FOREST GROWS. (EBF) 1 reel, color. Shows how forests grow from seed to trees. Discusses the relation of temperature and rainfall to the growth of trees.

GARDENING. (EBF) 1 reel, b/w. Shows how a garden was planted and raised by a boy and a girl. Describes the cultivation and harvesting of common vegetables.

JUNGLE GIANTS. (TFC) 1 reel, b/w. Shows the studies made of African wild life, such as that of elephants and lions, in native habitats.

MAMMALS OF THE COUNTRYSIDE. (Cor) 1 reel, b/w & color. Shows common wild animals as helpful or harmful to the farmer. Includes skunk, red fox, woodchuck, and other animals living in a field-woodland community.

MAMMALS OF THE ROCKY MOUNTAINS. (Cor) 1 reel, b/w & color. Shows mammals typical of valley grasslands, wooded slope, alpine meadows, and barren heights. Mountain goats, bighorn sheep, mule deer, and porcupines are included.

MAMMALS OF THE WESTERN PLAINS. (Cor) 1 reel, b/w & color. Buffalo, antelope, timber wolf, and other plant and meat-eating mammals are shown in their natural habitats.

PREHISTORIC TIMES: THE WORLD BEFORE MAN. (Cor) 1 reel, b/w & color. Depicts geological and biological developments during the earth's history. Shows fossil remains and models of prehistoric plants and animals.

SUMMER ON THE FARM. AUTUMN ON THE FARM. WINTER ON THE FARM. SPRING ON THE FARM. (See film list for Chapter 3.)

UNDERSTANDING OUR EARTH: GLACIERS. (Cor) 1 reel, b/w & color. Con-

siders glaciers of Canada, Europe, and the United States, including those in Alaska. Shows the kinds and how they are formed.

WILD LIFE ON THE DESERT. (Calif U) 1 reel, b/w. Depicts wild animals in a desert community between the Rocky Mountains and the Sierra Nevadas.

THE ZOO. (EBF) 1 reel, color. A visit to the Chicago Zoological Park is pictured. Polar and kodiak bears, lions, tigers, kangaroos, alpacas, giraffes, zebras, baboons, sea lions, hippopotami, rhinoceri, and elephants are seen at close range.

Filmstrips

AGE OF MAMMALS. (EBF) color.

ANIMALS OF LONG AGO. (Curr F) color.

THE RISE OF THE DINOSAURS. (EBF) color.

THE STORY FOSSILS TELL. (EBF) color.

VI

Chemicals Everywhere

"Let's do chemistry experiments!" is often the cry of ten- and eleven-year-olds. Putting substances together to obtain different substances with a new color or a strange odor is a fascinating experience. "Chemicals Everywhere" presents safe experiences with common materials which may help to satisfy this urge. In addition, it is hoped that children will gain some appreciation of the fact that all things on the earth are composed of only a few basic materials.

Science Meanings for Children

Talking with children about chemicals and chemistry probably will reveal that their conceptions lean toward the spectacular. To many children chemicals are substances which explode.

You will want to make it possible for children to gain some of the following meanings:

The earth and all the things on it are made of chemicals. We use chemicals every day.

The basic chemicals of which all other materials are made are known as elements. Man has been able to make new elements.

Chemical mixtures can be taken apart. Making chemical mixtures does not change the original chemicals.

When chemicals are put together to form a compound, an entirely new substance is made. Thousands of chemical compounds may be made by combining the basic elements. Taking chemical compounds apart is difficult.

Heat and light cause certain chemical changes.

Chemists identify unknown chemicals in various ways.

Information for You

A shelf of chemicals in the classroom need not and should not include dangerous substances. Certainly there should be no strong acids in the classroom at any time. Such common materials

as salt, sugar, pieces of metal, vinegar, baking soda, baking powder, alcohol, fingernail polish remover, lemons, grapefruit, and onions are chemicals which are useful in helping children explore this fascinating area of science. If chemistry means to you the balancing of chemical equations or the use of strong acids, perhaps you will want to revise your notion of chemistry. Polishing silver, baking cookies, or taking a picture are common experiences which you have had with chemistry. You will find it interesting to help children experience their environment as a world of chemicals.

There are about one hundred basic chemicals known to men. All the living and nonliving things of the earth are made of one or more of these elements.

A list of the elements now known to scientists, together with their symbols, appears in Chart 4, page 80. Some of these you will know. There is no great value in your knowing all of the elements. But you may have some need of this table as source material.

Scientists working in the field of atomic energy have produced certain elements by causing changes to take place in previously known elements. Among the elements thus produced are neptunium (Np), plutonium (Pu), americium (Am), curium (Cm), berkelium (Bk), and californium (Cf). It is possible that scientists will produce other elements in the course of their researches with atomic energy.

Unless a substance is made of only one of these elements, it is made of a combination of them. All living things, including man, are made of elements. This is true of nonliving things as well. We are a part of and live in a world of chemicals.

The smallest part of any element is an atom of that element. Hence, there are as many different kinds of atoms as there are elements. The lightest atom now known to man is the hydrogen atom; the heaviest is the californium atom.

When we combine two or more elements chemically, a chemical compound is produced. For instance, a chemical combination of iron and oxygen produces iron oxide or rust. Other common compounds are quartz made from silicon and oxygen; sugar made from carbon, hydrogen, and oxygen; starch made from different proportions of carbon, hydrogen, and oxygen; salt made from sodium and chlorine; sulfuric acid made from hydrogen, sulfur, and oxygen; baking soda made from sodium, hydrogen, carbon, and oxygen; lye

made from potassium, oxygen, and hydrogen; gasoline made from carbon and hydrogen; alcohol made from carbon, hydrogen, and oxygen; and water made from hydrogen and oxygen.

It is difficult to cause chemical compounds to break down into their original elements, but it is possible. For instance, water can be broken down into hydrogen and oxygen by the use of electricity. It

CHART 4 · THE ELEMENTS AND THEIR SYMBOLS*

actinium	Ac	gold	Au	promethium	Pm
aluminum	Al	hafnium	Hf	protactinium	Pa
americium	Am	helium	He	radium	Ra
antimony	Sb	holmium	Ho	radon	Rn
argon	A	hydrogen	H	rhenium	Re
arsenic	As	indium	In	rhodium	Rh
astatine	At	iodine	I	rubidium	Rb
barium	Ba	iridium	Ir	ruthenium	Ru
berkelium	Bk	iron	Fe	samarium	Sm
beryllium	Be	krypton	Kr	scandium	Sc
bismuth	Bi	lanthanum	La	selenium	Se
boron	B	lead	Pb	silicon	Si
bromine	Br	lithium	Li	silver	Ag
cadmium	Cd	lutetium	Lu	sodium	Na
calcium	Ca	magnesium	Mg	strontium	Sr
californium	Cf	manganese	Mn	sulfur	S
carbon	C	mercury	Hg	tantalum	Ta
cerium	Ce	molybdenum	Mo	technetium	Tc
cesium	Cs	neodymium	Nd	tellurium	Te
chlorine	Cl	neon	Ne	terbium	Tb
chromium	Cr	neptunium	Np	thallium	Tl
cobalt	Co	nickel	Ni	thorium	Th
columbium	Cb	nitrogen	N	thulium	Tm
copper	Cu	osmium	Os	tin	Sn
curium	Cm	oxygen	O	titanium	Ti
dysprosium	Dy	palladium	Pd	tungsten	W
erbium	Er	phosphorus	P	uranium	U
europium	Eu	platinum	Pt	vanadium	V
fluorine	F	plutonium	Pu	xenon	Xe
francium	Fr	polonium	Po	ytterbium	Yb
gadolinium	Gd	potassium	K	yttrium	Y
gallium	Ga	praseodymium	Pr	zinc	Zn
germanium	Ge			zirconium	Zr

*It is not intended that this chart be "taught." Children should not be required to memorize this material. The chart is presented only as background information which may be useful to you as you help children find answers to their questions concerning chemicals.

is easier to separate mixtures of elements since the elements retain their separate identities when they are mixed.

Some common chemical mixtures are sugar and water; carbon dioxide and water, which make "soda" water; air and water; lemon juice and sugar; salt and pepper; and sugar and cinnamon.

Heat and light often bring about or hasten chemical changes. Heat and light may cause changes which produce new chemical combinations. Light is responsible for producing new chemical compounds on a photographic film or plate. Heating an element may cause it to combine with oxygen, or burn, thus producing a new chemical compound.

Chemists identify chemicals by taste, color, odor, reaction to other known chemicals, and so on. We also identify and describe many materials in this way.

Helping children understand that chemicals are not unusual materials but are the common substances of which the earth is made will be a rewarding experience for you.

Ways of Working with Children

A consideration of chemistry may be initiated through a cooking experience such as baking bread, making junket, or preparing cookies. Discussion may bring out the fact that putting certain materials together and heating them produces a new substance. This process involves the use of chemicals and brings about chemical change. Or you may wish to use pages 110–111 of *Adventuring in Science* to initiate the study. Every object shown in the picture on these pages is made of chemicals.

As the discussion proceeds, the question "What is a chemical?" probably will arise. Here you may wish to introduce the idea that there are about one hundred basic chemicals called elements. The complete list of elements now known to man is given in Chart 4 on page 80 of this Manual. A partial list appears on page 113 of *Adventuring in Science*. You will want to note that the smallest part of any element is an atom of that element. No one has ever seen individual atoms, since they are far too small to be seen with even the most powerful microscope. But we make use of atoms every minute of every day. Indeed, we are made up of atoms.

It is suggested that children consult a dictionary to discover why copper has been given the symbol Cu, lead the symbol Pb, and so on.

Cu for copper is from the Latin word *cuprum*; Pb for lead is from the Latin word *plumbum*; Hg for mercury is from the Latin word *hydrargyrum*; Ag for silver is from the Latin word *argentum*; Na for sodium is from the Latin word *natrium*; Sn for tin is from the Latin word *stannum*; and W for tungsten is from the German word *wolfram*. Incidentally, tungsten is from the Swedish words *tung*, or heavy, and *sten*, or stone.

Some of the elements, such as carbon, sulfur, iron, copper, silver, tin, gold, mercury, and lead, have been known since ancient times. Most of the other elements have been identified since 1700. For example, platinum was identified in 1727, oxygen and chlorine in 1774, uranium in 1789, iodine in 1812, aluminum in 1827, radium in 1898, neptunium and plutonium in 1940, americium and curium in 1944, and berkelium and californium in 1951.

Some of the elements, such as aluminum, gold, silver, tin, mercury, platinum, and tungsten, are metals. Some, such as oxygen, argon, hydrogen, chlorine, and helium, are gaseous at ordinary temperatures. Some, such as oxygen, hydrogen, and helium, are invisible.

Elements may be put together to form chemical mixtures. You will want to encourage your children to make and take apart the mixtures described on pages 114–117 of *Adventuring in Science*. Help them to understand that chemical mixtures can be taken apart rather easily, since no new chemicals are formed in the process.

When elements combine chemically, a new substance known as a compound is formed. The experiments on pages 118–120 of *Adventuring in Science* describe three ways to produce the chemical compound carbon dioxide. Each molecule of carbon dioxide, CO_2, is composed of one atom of carbon and two atoms of oxygen. Compounds such as this are difficult to separate into their elements. The process of burning is a process of forming new chemical compounds. When any material burns, it combines with oxygen to form a new chemical compound.

You may want to help children understand that chemists have several ways of identifying chemicals. Let them test vinegar, sour milk, fruit juices, ammonia, a baking-soda solution, a table-salt solution, and a sugar solution to determine if they are acids. An acidic solution will turn blue litmus paper to a pinkish-violet color. Alkaline solutions will not affect blue litmus paper but will turn pink

litmus paper to blue. Salt solutions will affect neither pink nor blue litmus paper.

Following are common materials with the acids they contain:

Acids Found in Common Materials

Citric acid in	grapefruit juice lemon juice orange juice	Tannic acid in	stewed rhubarb tea coffee
Lactic acid in sour milk		Acetic acid in vinegar	
Boric acid in boric acid solution			

The chemical test for starch described on page 126 of *Adventuring in Science* tried on crackers, rice, white cake, and laundry starch will obtain the same results as when used on bread or white potato. If iodine is used on foods containing little or no starch, the area colored by the iodine will remain brown rather than turn blue.

Perhaps you will want to tell your children of an important way astronomers used the chemists' knowledge that each element would glow with its own particular color when heated very hot, and thus produce certain special bright lines when viewed through a spectroscope, an instrument containing a very fine prism. Astronomers in studying the sun's spectrum, produced by allowing sunlight to pass through a spectroscope, noted the usual band of dark lines. When chemists heated the various elements to incandescence and examined these very hot elements through a spectroscope, they saw that each element produced bright lines which corresponded in position and width to the dark lines in the sun's spectrum. Chemists were able to produce almost all the bright lines corresponding to the dark lines in the sun's spectrum. But no known element could produce lines corresponding to certain dark lines. Therefore, the chemists began the search for a new element which would produce the missing lines when that element was heated to incandescence. At last, in 1895, they discovered such an element—an odorless, very light element which was gaseous and colorless at ordinary temperatures. This important element was named helium after the Greek word for the sun *helios*.

This is an example of the way in which scientists work together. Astronomers first noted that an element might be present on the sun which had not yet been isolated on the earth. The chemists, with

their special knowledge, were finally able to discover on the earth the element which when heated to incandescence produced the previously unidentified lines in the sun's spectrum.

Materials Needed

ammonia

baking powder
baking soda
blueprint paper
boric acid
bowl
bread, white

candles, 4 birthday, and 1 large
cardboard, 3 pieces, $1\frac{1}{2}$ inches square
cloth, 12-inch square, blue, inexpensive
cornstarch
cream of tartar

flour
food coloring

glass, 6-inch square

ice
iodine
iron filings (available at machine shops and scientific supply houses)

jars, pint and quart

leaf
lemon juice
litmus paper, pink and blue (available at drug stores)

matches, small box
matchsticks, with heads clipped off
measuring cup
measuring spoons

onion juice

pan
paper, sheets of heavy writing
paper, long strip of heavy
paper towels
pencil
potato, white
pot holder

rubber tube, to fit spout of teakettle

salt, table
saucer
screw
skillet
soda-water bottle, with cork
sour milk
Sterno stove or electric plate
string
sugar

teakettle
teaspoons, 2
tumbler

vinegar

water
wire, 12 inches, stiff but bendable

Thinking about Man's Use of Chemicals

See suggestions for children, page 127, *Adventuring in Science.*

1. Gold, silver, platinum, and copper are used in jewelry. Brass, silver, copper, and tin are used in creating decorative household objects. Iron, aluminum, magnesium, and chromium are used in producing automobiles, machinery, and other objects. Tungsten is used in making the filaments in electric light bulbs.

The following information may be helpful, although it does not include all countries producing the minerals mentioned.

Iron ore is found in the United States, Great Britain, Soviet Russia, Cuba, Canada, Chile, France, Germany, Brazil, Sweden, Spain, Newfoundland, Australia, and India.

Bauxite from which aluminum is produced is found in the United States, Indonesia, Yugoslavia, British Guiana, France, Italy, India, Brazil, Canada, and Dutch Guiana.

Lead and zinc are found in the United States, Australia, Canada, Soviet Russia, and Mexico.

Copper is found in the United States, Peru, Northern Rhodesia, the Belgian Congo, and Chile.

Nickel is mined mainly in Canada.

Tin is found in Nigeria, the Belgian Congo, Mexico, Canada, and Australia.

Silver is found in Mexico, Peru, Bolivia, the Belgian Congo, the United States, and Canada.

Uranium is found in the Belgian Congo, Canada, Brazil, Spain, Soviet Russia, Union of South Africa, France, and the United States.

As scientists learn more about the world, they will probably discover other mineral deposits, particularly in India, Africa, and China.

2. Perhaps this experience will encourage some of your children to pursue photography as a hobby.

3. Boron gives a green color, sodium a yellow color, and potassium a red color.

4. Some things made of plastics are toys, raincoats, aprons, refrigerator dishes, buttons, combs, upholstery, and floor coverings.

5. Sugar formed in green leaves is the basis of our food supply because we feed upon green plants, nongreen plants, animals, and animal products. Nongreen plants and all animals are dependent

upon green plants for their food supply, since green plants are the only living things which can manufacture their own food directly from carbon dioxide and water in the presence of light. All other living things are dependent upon this basic food-making process of green plants.

Further Activities

1. Make some solutions in water. Sugar and salt will dissolve in water, but chalk dust and sand will not.

2. Experiment to understand that substances will dissolve in hot water faster than they will in cold water. For example, at the same time, drop a lump of sugar into a cup of hot water and another lump of sugar into a cup of cold water. Stir the contents of both cups and note how long it takes the sugar to dissolve in each.

3. Shellac will dissolve in alcohol but not in water. To show this, crush enough sealing wax, which is colored shellac, to make a teaspoonful. Put this in a glass of cold water and stir. Now put the same amount of sealing wax in a glass and cover it with about one inch of alcohol. Use denatured alcohol which may be purchased at a hardware store. Rubbing alcohol will not work well since it contains too much water. Cover the glass containing alcohol and sealing wax so the alcohol will not evaporate. Examine the contents after two hours. Note that the sealing wax has dissolved in the alcohol.

4. Make salt crystals by dissolving two teaspoons of table salt in a cup of water. Heat this solution. Salt crystals will be left in the pan when the water has evaporated. Examine the crystals with a magnifying glass. Notice that each crystal looks like a small block.

5. Secret writing may be done with a clean matchstick or a pen and milk. When the paper on which the writing has been done is heated, the writing will turn brown.

Was It Worth While?

This is an excellent area in which to help children work with real purpose. Some children will tend to approach experimenting with chemicals in a hit-or-miss fashion. Perhaps this can be avoided if before the children approach these materials they have a plan in mind. What do they propose to discover? What materials are needed? What rules of safety should be followed? Are pot holders available? Is a pan of water nearby when a lighted candle is

being used? Ten- and eleven-year-olds are mature enough to appraise their growth in this direction. Help them to do so by checking with them from time to time.

Have some of your children received unusual stimulation from this area? Have they experimented at home? Have they proposed new experiments? Have they searched in other books for material in this area?

Many of your children will wish to make a chemistry experiment book if they are provided the opportunity. Before recording an experiment in his book, ask the child to prepare a rough draft for you to see. Make sure that all materials used are listed and the directions are clear. Does his recording technique improve as he prepares records of new experiments for his book? Making original, individual chemistry books will be a more valuable learning experience than copying directions for experiments from the board or a book. The latter exercise becomes an exercise in penmanship rather than an individual exercise in organization.

Perhaps the most important area of evaluation will be that relating to social values. In this respect, you may want to evaluate in terms of such ideas as these:

1. Are individuals in this group becoming more aware of the uses man is able to make of the basic elements?
2. Are children more conscious of new synthetic fabrics and other materials which are appearing on the market?
3. Have the children become more aware of the care and knowledge which chemists use in producing new materials?
4. Is there any indication of the children appreciating the fact that the tremendous variety of living and nonliving things of the earth is made of about one hundred basic elements?

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Films

CRYSTAL GAZERS. (GE) 1 reel, b/w; free. Shows the characteristics of crystals and ways the scientist uses these characteristics in identifying crystals.

MAKING GLASS FOR HOUSES. (EBF) 1 reel, b/w. Describes how limestone, sand, and soda ash are obtained and used in making glass. A simple laboratory demonstration, as well as the full-scale factory production, of glass making is shown.

PLACER GOLD. (Barr) 1 reel, b/w. Shows how placer mining was used by early miners in California. Depicts gold-pan, rocker or cradle, long-tom, and sluice-box methods of mining gold.

ROMANCE OF RADIUM. (TFC) 1 reel, b/w. Gives the story of the discovery of radium by Madame Curie.

SIMPLE CHANGES IN MATTER. (Cor) 1 reel, b/w & color. Shows simple physical and chemical changes, such as seedling growth, soil erosion, expansion of metals, ice melting, color change in leaves, logs decaying, and metal rusting.

SOLIDS, LIQUIDS, AND GASES. (See film list for Chapter 2.)

STEEL—MAN'S SERVANT. (US Steel) 4 reels; industrial film. Describes the mining and processing of iron ore.

STORY OF COPPER. (US Bur Mines) 3 reels, color; free. Shows the mining, milling, smelting, and refining of copper.

SYNTHETIC FIBERS—NYLON AND RAYON. (EBF) $1\frac{1}{2}$ reels, b/w. Shows simply but clearly how these fibers are produced, and some of their uses by man.

WONDERS OF CHEMISTRY. (YAF) 1 reel, b/w. Describes chemistry as a science. Explains elements, compounds, and chemical change. Shows how man makes use of his knowledge of chemistry.

Filmstrip

ALL MATTER HAS THREE FORMS. (YAF) b/w.

VII

Animals Grow and Change

Animals live everywhere in the world, and they are a constant source of fascination for children. The material in the chapter "Animals Grow and Change" presents information involving comparisons. You will probably want to emphasize the variety of animals, the adaptations, and the likenesses and differences found among them. Through this study it is hoped that children may become more aware of the values of animal life in the community. They should become more conscious also of the proper care of animals.

Science Meanings for Children

The children in your group will have formed many correct concepts concerning animals, among which may be that animals are living things and that all animals are dependent upon green plants for their food supply. A common misconception is that *animal* and *mammal* are synonyms. Among the learnings which may come from the use of "Animals Grow and Change" is the fact that mammals are animals, and that birds, reptiles, fish, insects, and beetles also are animals.

Other meanings which may be developed follow:

Animals change as they grow. Cotton boll weevils change from eggs to larvae to pupae to adult weevils as they grow. Potato bugs and ladybird beetles go through these same stages as they grow.

Young grasshoppers look very much like adult grasshoppers except that they are smaller.

Butterflies and moths go through the same stages as they grow as do cotton boll weevils.

Amphibians are born in the water, obtain air by the use of gills during the first part of their lives, and later develop lungs.

All young reptiles look very much like their parents except that they are smaller. Some reptiles are hatched from eggs; others are born alive.

Young fish look very much like their parents except for the difference in size. Some fish hatch from eggs; others are born alive.

Young birds look very much like their parents. All birds are hatched from eggs. Birds have feet and beaks which are much alike. Birds are the only animals which have feathers.

Many of our familiar animals are mammals. All young mammals look very much like their parents, and all feed on milk from their mothers' bodies. Only a few kinds of mammals are hatched from eggs; all the others are born alive.

There are many likenesses and differences among animals.

Some animals are useful to man; others are harmful.

Information for You

Although this chapter does not deal with one-celled and other microscopic animals, you may need some information concerning the scientific grouping of animals, as well as examples and numbers of different kinds of animals in each group. This information is given in Chart 5. It is amazing to notice that there are approximately a million different described species of animals living in the world today.

None of these animals is capable of manufacturing its own food; all depend upon green plants for their food supply. Another likeness among animals is that they all are made of cells. Some are one-celled; others have many cells. Some animals have no skeletons; some have outer skeletons or shells; others have simple or well-developed internal skeletons. Some animals, such as amphibians, fish, and reptiles, are cold-blooded; others, such as birds and mammals, are warm-blooded. A cold-blooded animal's body temperature varies with the air or water around it, while a warm-blooded animal's temperature remains constant or nearly so.

One-celled animals reproduce by cell division. Some many-celled animals are egg layers; others bear their young alive. Some animals are water dwellers, some are soil dwellers, others are land or air dwellers.

Obviously, there are many likenesses and differences to be found among the million or so different kinds of animals. You and your children will want to use a number of reliable sources to answer specific questions concerning specific animals. It is suggested that each classroom have at least one comprehensive animal field guide

containing pictures of animals, as well as descriptions of their characteristics and habits. Or a group may wish to have several such guides, one on birds, one on mammals, one on insects, and so on.

CHART 5 · GROUPS OF ANIMALS*

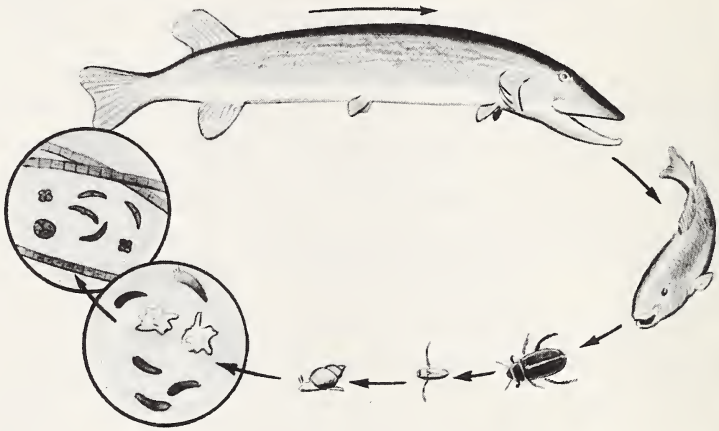
Scientific Name	Common Name	Number of Described Species	Examples
PROTOZOA	One-celled animals	20,000	Amoeba, paramecium
PORIFERA	Sponges	3,000	Fresh-water sponges, bath sponges
COELENTERATA	Two-layered bodies	10,000	Hydra, jellyfish, coral, sea anemone, sea fan
CTENOPHORA	Comb jellies	100	Comb jellyfish, walnuts
PLATYHELMINTHES	Flatworms	7,000	Planaria, tapeworms
NEMATHELMINTHES	Roundworms	3,000	Hookworm
ROTIFERA	Wheel animals	1,800	Philodina
BRYOZOA	Moss animals	3,000	Vulture-headed moss animal, comb moss animal
BRACHIOPODA	Lamp-shell animals	130	Magellania
ANNELIDA	Segmented worms	7,000	Earthworms, leeches
ECHINODERMATA	Spiny-skinned animals	5,000	Starfish, brittle star, sea urchin, sea lily, sea cucumber
MOLLUSCA	Soft-bodied animals	78,000	Snails, slugs, limpets, whelks, oysters, clams, mussels, scallops, squids, octopi, devilfish
ARTHROPODA	Jointed-footed animals	700,000	Crayfish, shrimps, lobsters, crabs, centipedes, millipedes, grasshoppers, crickets, praying mantes, termites, ant lions, dragonflies, bird lice, true bugs, cicadas, aphids, beetles, caddis flies, butterflies, moths, flies, mosquitoes, gnats, fleas, bees, wasps, ants, spiders, ticks, mites, scorpions
CHORDATA	Spinal-cord animals	70,000	Sea squirts, lampreys, fish, amphibians, reptiles, birds, mammals

*It is not intended that this chart be "taught." Children should not be required to memorize this material. The chart is presented only as background information which may be useful to you as you help children find answers to their questions concerning animals.

Ways of Working with Children

If you find it necessary to stimulate interest in animal life, use the pictures on pages 128–129 of *Adventuring in Science.* Here we find ten young animals. Some children confuse the words *animal* and *mammal.* Help them to understand that a kitten is a mammal and also an animal. Help them to see that grasshoppers, snakes, fish, birds, butterflies, frogs, earthworms, boll weevils, and salamanders also are animals.

The fact that no animal is capable of manufacturing its own food



may lead to a study of food chains. For instance, pickerel feed on young and adult black bass, which feed on large water insects, which feed on smaller water insects, which feed on pond snails, which feed on one-celled animals or protozoa, which feed on small, living green plants or decaying plant material. A simpler food chain involves people who feed on meat and milk from cattle, which feed on living green plants or plant products, which were once living.

"Animals Change and Grow" tells the life story of several representative forms of animal life. You may want to use this information in two ways: to help children gain a broad picture of different forms of animal life, and to introduce more intensive considerations of forms of animal life through the examples described.

Referring to Chart 5 on page 91 of this Manual, you will see that beetles, of which the cotton boll weevil is an example, belong to the

jointed-footed animals. Help children understand that all the animals in this group have jointed legs. It may seem strange to classify lobster, centipedes, beetles, moths, and scorpions in the same group until this likeness is pointed out.

Beetles belong to the insect group, which is a subgroup of the jointed-footed animals. Beetles, as well as all other insects, have bodies divided into head, thorax, and abdomen. One pair of antennae is found on the head of insects, and three pairs of legs, as well as one or two pairs of wings, are usually fastened to the thorax. Some insects, such as silverfish, do not go through metamorphosis as they grow to adulthood. On the other hand, beetles and butterflies do go through complete metamorphosis. As your children study this material, you may want to emphasize the four stages in complete metamorphosis; that is, the egg stage, the larva or grub or caterpillar stage, the pupa or resting stage, and the adult stage. Study the pictures on pages 130–131 of *Adventuring in Science* to gain a clearer concept of these changes.

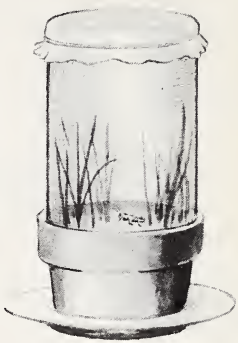
Another important misunderstanding concerns the indiscriminate killing of beetles. While cotton boll weevils and Colorado potato bugs should be destroyed because they are exceedingly harmful to crops, ladybirds should not be harmed, since they feed on many kinds of plant lice as well as on the eggs of the asparagus beetle, Colorado potato beetle, grape-root worm, alfalfa weevil, and chinch bug. Ladybirds also feed on the San Jose scale insect which attacks orange trees. Because of this, California orange growers collect thousands and thousands of these beetles and set them free in orange groves. It is believed that about 30,000 ladybirds will protect a ten-acre orange grove from San Jose scale.

Carpet beetles, May beetles, Japanese beetles, Colorado potato beetles, elm leaf beetles, plum curculio, engraver beetles, and alfalfa weevils are examples of beetles which cause millions of dollars' worth of damage each year.

Grasshoppers are also insects, being most closely related to crickets, katydids, cockroaches, locusts, and praying mantes. These insects do not go through complete metamorphosis. The egg, nymph, and adult stages in the life of a grasshopper are shown on page 134 of *Adventuring in Science*. Notice that the nymph looks quite like an adult grasshopper, even though its head is much larger in comparison with the remainder of its body.

Encourage children to observe insects, to notice the antennae, the paired legs, the wings, and the three parts of the body. Unless an insect is harmful, it should be released after observation. A cage, such as the one shown here, makes it possible to observe insects without injuring them.

Honeybee



Some grasshoppers and closely related animals are harmful to man. Grasshoppers feed on grain crops, western crickets damage much grain, field crickets feed on grain and clothing, cockroaches feed on foodstuffs and carpets, and lesser migratory locusts feed on grain crops. On the other hand, snowy tree crickets feed on plant lice, and praying mantes feed on many harmful insects.

Probably children are most familiar with complete insect metamorphosis as it is exemplified in the life cycles of butterflies and moths. Help the children study the pictures on pages 136–139 of *Adventuring in Science* to gain clearer concepts of metamorphosis and to gain clearer ideas of the relative sizes of butterfly and moth eggs, larvae, pupae, and adults.

Perhaps your children will be interested in some of the facts given in Chart 6 concerning butterflies and moths. Of course, these are but a few of the many known butterflies and moths, of which some nine thousand kinds live in North America north of Mexico.

Among these many thousand insects, some are harmful. Among the most destructive are certain moths and butterflies in the larva or caterpillar stage. These include clothes moth caterpillars; codling moth caterpillars, which feed on apples; closewing moth caterpillars, which destroy corn leaves; apple tent moth caterpillars,

CHART 6 · DISTINGUISHING CHARACTERISTICS OF SOME COMMON BUTTERFLIES AND MOTHS

Characteristics	Butterflies		Moths	
	Monarch	Tiger-swallowtail	Gypsy	Cecropia
Wingspread	4 inches	5 inches	$1\frac{1}{2}$ inches	$6\frac{1}{2}$ inches
Where usually found	Most of United States and southern Canada	Southern Canada and most of United States, except west coast	New England and southeastern Canada	Atlantic coast to Rocky Mountains
Hatching time of eggs	4 days	10 days	All winter	15 days
Length of larvae	$2\frac{1}{2}$ inches	2 inches	2 inches	4 inches
Food of larvae	Leaves of milkweed	Leaves of ash, birch, poplar, and cherry trees	Leaves of shade and fruit trees, as well as conifers	Leaves of box elder, apple, cherry, willow, and plum trees
Harmful	No	No	Yes	No

which destroy the leaves of fruit trees; forest tent moth caterpillars, which destroy the leaves of many fruit and shade trees; sphinx moth caterpillars, which feed on the leaves of tomato and tobacco plants; army worm moth caterpillars, which feed on small grain plants; dingy cutworm moth caterpillars, which feed on newly planted crops; and cabbage butterfly caterpillars, which feed on the leaves of plants of the cabbage family. Most butterflies and some moths are not abundant enough to warrant taking control measures. And, of course, the silkworm moth is so useful that man protects it. Another interesting helpful moth is the yucca moth, which pollinates the flower of the yucca plant. It is believed that yucca plants would die out completely if it were not for this moth.

Again, referring to Chart 5 on page 91 of the Manual, we find that salamanders, members of the group known as amphibians, belong to the group of animals with spinal cords. These cold-blooded animals probably live in your community. In the late spring, take a walk to a nearby park or woods and try to locate salamanders. They will often be found under stones or logs.

If it is possible, bring some salamander eggs to the classroom and care for them by placing them, together with some of the water in which they were found, in an enameled or glass container. When the eggs hatch, water plants should be introduced into the aquarium

so that the young salamanders have a place on which to rest. For a time, the animals feed on the jelly of the egg mass, but later they must be given additional food. About once a week, remove the salamanders to a small bowl of tepid water. Place tiny pieces of lean beef or liver in the dish and allow the animals to feed.

When the salamanders lose their gills, they should be removed to a home such as the one described on pages 141–142 of *Adventuring in Science*. When there has been sufficient observation of the animals, they should be returned to their natural environment.

As you study the picture on page 142 of *Adventuring in Science* you may want to know the usual sizes of the adult salamanders. Hellbenders grow to about 24 inches in length, mud puppies to about 12 inches, newts to about 4 inches, and red efts to about 2 inches.

Again, help children understand that salamanders are animals, that they belong to the amphibian group, as do frogs and toads. Help them to see that the young of amphibians look very little like adult amphibians.

Snakes are also cold-blooded animals. They are also animals with spinal cords, but they belong to the reptile rather than the amphibian group. Reptiles other than snakes are turtles, alligators, crocodiles, Gila monsters, horned toads, and other lizards.

Help your children understand that reptiles look very much like their parents as soon as they are born, except that they are smaller. Young reptiles must fend for themselves, as the female does not care for her young.

Fish also are cold-blooded animals belonging to the group of animals with spinal cords. They must spend all of their lives in the water, since they are unable to breathe air as reptiles or adult amphibians do.

Many kinds of fish lay eggs and leave the eggs to hatch unprotected. A few fish, such as the European stickleback shown on page 148 of *Adventuring in Science*, and bluegills, build nests and care for their young. Many varieties of tropical fish bear their young alive. One of the most common of the livebearers with which your children may be familiar is the guppy.

Your children will be fascinated by the migrations of eels and salmon. Help them to locate and use material telling of the migrations of these fish. They will also be interested in the economic importance of fish for food, oil, and fertilizer.

Birds and mammals are the only warm-blooded animals. Birds are the only animals with feathers. All birds are hatched from eggs and breathe with lungs all their lives. Almost all birds build nests and care for their young, one of the exceptions being cowbirds, which lay their eggs among the eggs of other birds.

As you observe birds and study about them note the many likenesses and differences among them. Help children to observe carefully the feet, beaks, and feathers of birds as suggested on page 155 of *Adventuring in Science.* Children need to have real experiences upon which they may base their conclusions.

Mammals are warm-blooded animals also. All mammals have hair on their bodies and feed their young on milk. Almost all mammals bear their young alive and care for them very well.

Use some of the films suggested at the end of this chapter for clarification of ideas relating to this material.

If you wish, keep mammals in your classroom for a time, but be sure that the animals are well cared for and are observed carefully by the children. No animal should be kept in the classroom unless children are interested sufficiently to give it proper care.

Help children to understand the likenesses and differences among mammals. Help them to understand that mammals change as they grow, but that they look much like their parents when they are born

Materials Needed

aquarium or widemouthed jar

bird seed
board, 2 feet wide and length of window sill
boards, 4 pieces 1″ × 1″ × 18″
boards, 4 pieces 1″ × 1″ × 4′
boards, 4 pieces 1″ × 1″ × 3′
box, screened on one side
box, wooden, 8″ × 8″ × 12″

cheesecloth, ½ yard
cocoons and chrysalises

dishes, 2 cereal
dish, small shallow

earthworms, snails, liver, or beef

fish
flowerpot, 8 to 10 inches in diameter

glass, 1 piece, ½ inch wider and longer than baking pan
glass, 1 piece, 2 feet wide and length of window sill
glass, 4 pieces, 8 inches high, and lengths to fit exactly inside 4 sides of baking pan

grasshopper eggs
gravel, 8 cups
guinea pigs, pair
loam, 12 to 15 cups
nails
newspapers
pan, shallow baking
plants, water
plants, woodland
salamanders
sand, to cover aquarium $1\frac{1}{2}$ inches
seed, grass
soil, to fill flowerpot
wire mesh, 18″ × 15′
wire screen, 18″ × 3′

Discuss These Things

See suggestions for children, page 160, *Adventuring in Science.*

1. It is far better to observe plants and animals in their natural environments. There they are not so easily injured and the animals are freer in their movements. If animals are brought into the classroom, there should be a real reason for bringing them. Careful plans should be made so that the animals remain healthy.

2. Encourage children to test opinions. Help them to seek authoritative sources.

You Might Like to Try These

See suggestions for children, pages 160–161, *Adventuring in Science.*

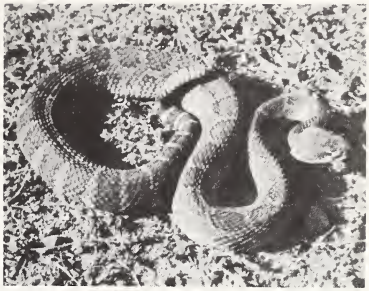
1. Small native fish or goldfish may be kept in the aquarium. If tropical fish, such as guppies, are used, the water should be kept at a temperature of about 72° F. Do not place the aquarium in direct sunlight, since sunlight promotes the growth of green algae on the sides of the aquarium. Feed the fish every other day, feeding them only as much as they will eat in five minutes. Remove all uneaten food from the aquarium. Snails should be kept in the aquarium; they remove algae and other materials not wanted.

2. The feeder should be in a quiet place.

3. The four poisonous snakes in North America are coral snakes, water moccasins or cottonmouths, copperheads, and rattlesnakes. Coral snakes are found from South Carolina to Florida, the Gulf states, New Mexico, and Arizona. They have been found as far north as Pennsylvania and New York. Water moccasins are found from Virginia south, and westward through Texas and Oklahoma. Copperheads are found from New England to Florida, and westward

N.Y. Zoological Society

Water moccasin



William Graf

Rattlesnake

Nature Magazine

Copperhead

N.Y. Zoological Society

Coral

to Illinois, Texas, and Arkansas. Rattlesnakes are found in all parts of North America.

4. Help children appreciate the fact that domesticated animals need special care from man.

Further Activities

1. Encourage children to make and prepare oral and/or written reports concerning an animal of their own choosing. Help them to place the animal in its proper group, discover how it grows and changes, and what its habits and characteristics are.

2. Children may be interested in preparing riddle-descriptions of various animals. As a child reads his riddle aloud ask the other children to try to guess the name of the animal described.

3. Make a survey of the different animals found in your community. Prepare a class booklet, a mural, or a bulletin board showing these animals.

4. Discuss the values of birds, snakes, and mammals to man. Help children understand that few of these animals are harmful and that they should not be killed indiscriminately.

5. Take leisurely walks with your group, keeping a sharp eye out for animal life. Do this at different seasons of the year. Keep a record of the animals seen on your walks. At the end of the year, note which are the probable migrators or hibernators.

6. If there is a zoo nearby, visit it with your group so that you may see animals from other environments.

7. Have a pet show. Stress the proper care of animals, not the pedigree of the animal. Perhaps you will want to use the film *Care of Pets* in conjunction with the show. (See page 103.)

8. Make a suet holder of wire, fill it with suet, and hang it from a tree during the winter. Observe the birds which come to feed there.

Was It Worth While?

1. You may want to check on correct conceptions and misconceptions your children have concerning animals. Perhaps you will want to ask them to fill out a chart of this kind.

CHART 7 · SOME CHARACTERISTICS OF ANIMALS WE HAVE STUDIED

Animal	Characteristics			
	Warm-blooded or Cold-blooded	How It Gets Air	Body Covering	How It Is Born
Insects	Cold-blooded	Through tubes along sides of thorax and abdomen	Scalelike	From eggs
Amphibians	Cold-blooded	Through gills, lungs	Skin	From eggs
Reptiles	Cold-blooded	Through lungs	Scales or scaly skin	From eggs or alive
Fish	Cold-blooded	Through gills	Scales or skin	From eggs or alive
Birds	Warm-blooded	Through lungs	Feathers and skin	From eggs
Mammals	Warm-blooded	Through lungs	Skin and hair or fur	From eggs or alive

2. Note the individual growth of children in ability to do research, to prepare, and to deliver a report. Are the children becoming better and better able to communicate their ideas? Is there growing pride in a good job, well done?

3. Have attitudes concerning animals changed? Is there some evidence of a change from an "All snakes are bad" attitude to a "Most snakes are useful because they destroy harmful rodents and insects" attitude? Is there increasing evidence of an attitude toward conservation of animal life rather than destruction of it?

4. Perhaps some of your children have shown an unusual interest in animal life. Have you helped them pursue this interest by suggesting books and activities for out-of-school as well as in-school use?

5. Is there evidence that your children have grown in their understanding of the wide variety of animal life? Are they more conscious of likenesses and differences among animals, as well as the great number of animals? Are they beginning to understand that it is a good thing that all animals are not alike?

6. Have you noticed changes in the realization of man's responsibility to animals? Are the children seeking better ways to care for pets? Are they concerned about indiscriminate killing of animals? Are they more willing to observe an insect for a short time and then release it in its natural habitat?

7. What evidence is there of changes in attitude in regard to the importance of animal life? Is there growth in understanding that all "bugs" are not harmful, that many are of great benefit to man?

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Films

ANIMALS GROWING UP. (EBF) 1 reel, b/w. Depicts the growth and care of chicks, puppies, and a calf. Chicks emerging from eggs, day-old puppies, and an hour-old calf are shown from these stages until they care for themselves.

BABY ANIMALS. (YAF) 1 reel, b/w. Shows how animals care for their young, how the young are like their parents, and points out some general growth patterns.

BEETLES. (EBF) 1 reel, b/w. Life stories of the ladybird beetle, Japanese beetle, and tiger beetle are shown. The importance of beetles to man is stressed.

BIRDS OF PREY. (EBF) 1 reel, b/w. Emphasizes the use made by these

birds of strong talons and sharp, hooked beaks in carrying and tearing apart their prey. Shows the development of owls, vultures, eagles, and hawks from young to adult.

BIRDS OF THE DOORYARD. (Cor) 1 reel, color. Describes in detail the living habits of common birds of a door-yard environment, including the white-throated sparrow, robin, house wren, yellow warbler, purple martin, and bronzed grackle.

BIRDS OF THE WOODLANDS. (Cor) 1 reel, color. Five birds native to the woodlands of northern North America are shown, including the redstart, purple finch, ovenbird, and northern flicker.

BUTTERFLIES. (EBF) 1 reel, b/w. Shows the life cycles of a cabbage butterfly and a swallowtail butterfly. Stresses their characteristics and habits.

BUTTERFLY BOTANISTS. (Cor) 1 reel, b/w & color. Depicts the life histories of several common butterflies.

CARE OF PETS. (EBF) 1 reel, b/w. Describes the care of pets in the home. Considers proper ways to care for canaries, tropical fish, cats, and dogs.

COMMON ANIMALS OF THE WOODS. (See film list for Chapter 5.)

DRAGONS AND DAMSELS. (ALF) 1 reel, b/w. Uses telephoto lens and time-lapse photography to show the life cycle of a dragonfly.

FROG. (EBF) 1 reel, b/w. Presents the life cycle of a frog from egg to full-grown frog.

JUNGLE GIANTS. (See film list for Chapter 5.)

LET'S VISIT A POULTRY FARM. (Cor) 1 reel, b/w & color. Shows the business of a modern poultry farm. The scene showing a chick emerging from the egg is especially interesting.

LIFE IN AN AQUARIUM. (YAF) 1 reel, b/w. Shows how an aquarium is made and maintained.

MONARCH BUTTERFLY. (IF) 1 reel, color. Depicts the complete life cycle of a monarch butterfly. Makes use of microphotographic close-ups.

MONARCH BUTTERFLY STORY. (EBF) 1 reel, color. Portrays in colorful detail the life cycle of a monarch butterfly.

MOTHS. (EBF) 1 reel, b/w. Life histories of the silk and white-masked tussock moths are shown in detail. Their economic importance to man is discussed.

NATURE'S NURSERIES. (Bray) 1 reel, b/w, silent. Shows the young fish, alligators, spiders, birds, deer, sheep, and bears.

PIPEVINE SWALLOWTAIL BUTTERFLY. (IF) 1 reel, b/w & color. A detailed study of the life cycle of a pipevine-swallowtail butterfly is shown.

POND INSECTS. (EBF) 1 reel, b/w. Life cycles and food habits of the dragonfly, May fly, and diving water beetle are presented.

THE RED-WINGED BLACKBIRD. (Cor) 1 reel, color. Traces the life story of this bird. Shows the annual migration.

ROBIN REDBREAST. (EBF) 1 reel, b/w. Presents the story of a robin family from the building of the nest by the parents to the time when the young robins care for themselves.

Snakes. (Cor) 1 reel, b/w & color. Considers the four poisonous snakes found in North America. Emphasizes the usefulness of most snakes to man.

Snakes Can Be Interesting. (YAF) 1 reel, b/w. Considers the life history of a common snake. Emphasizes the usefulness of snakes to man.

Snapping Turtle. (EBF) 1 reel, b/w. Describes the life story of this reptile. Shows the laying and hatching of eggs, the habitat, and hibernation of turtles.

Sunfish. (EBF) 1 reel, b/w. The life cycle of this animal from the laying and fertilizing of eggs to maturity is depicted.

Wild Animals—Their Homes and Habits. (Barr) 1 reel, b/w. Compares animal homes and shows how some birds and mammals care for their young.

Wonders in a Country Stream. (Churchill-Wexler) 1 reel, b/w & color. Two children discover several animals living in a stream. Shows the life cycles of a frog and a salamander.

Wonders in the Desert. (Churchill-Wexler) 1 reel, b/w & color. Shows horned toad, pocket mouse, desert tortoise, and other desert animals in their native habitats.

Filmstrips

How Amphibians Get Their Food. (Curr F) color.

How Animals Get Air. (SVE) b/w.

How Animals Get Food. (SVE) b/w.

How Animals Protect Themselves. (SVE) b/w.

How Insects Live and Grow. (SVE) color.

Insect Life Histories. (SVE) b/w.

Life Cycle of the Monarch Butterfly. (SVE) color.

VIII

About Balance and Shape

Children in their normal play activities have innumerable experiences with balance. They balance one another on a seesaw, or balance themselves as they walk precariously on a stone wall or a wooden fence rail. They have had practical experiences with balance through block-building and the use of construction toys. In addition, they are aware of the smooth, streamlined shapes of aircraft and automobiles. The chapter "About Balance and Shape" presents ways in which you may use this background of experience to point toward large understandings concerning balance and shape.

Science Meanings for Children

The extent to which a child incorporates a meaning in his own background of understanding depends upon the challenge of the meaning to him and upon his previous experiences. Of course you know that each child's version of the following meanings may be different from every other child's. Perhaps it is our most important opportunity and challenge to help each individual evaluate, strengthen, and deepen his accurate concepts.

Some of the meanings you may help children incorporate into their present concepts as you work through this material with them follow:

Things which are balanced have equal weights on either side of their central point.

The earth's gravity pulls things toward the center of the earth. The weight of a thing is the amount the gravity of the earth is pulling on that thing. Everything on the earth, as well as the earth itself, has its own gravitational pull.

Because it is rotating, the earth has centrifugal force.

On the earth centrifugal force and gravity oppose each other; this is the reason we neither fall off the earth nor are pulled completely to its center.

Some of the structures of the world have been standing a great

many years. At the time they were built, men may not have understood the principles of balance, but they used these principles, nevertheless. Engineers today make careful use of the principles of balance as they plan a new structure.

A smoother, more streamlined object can move through air or water more easily than a poorly designed object. The streamlining of automobiles, trains, ships, and aircraft not only makes them beautiful, but it also increases their speed.

Information for You

All of us have had experience with balance. As very young children, we learned to make use of the principles of balance in our block-building. Often we say that a vessel or a building or some other object must not be top-heavy if it is to stand properly. In other words, the base of a thing needs to be broader than the top, and the weight needs to be equally balanced around the center of the object if it is to be steady.

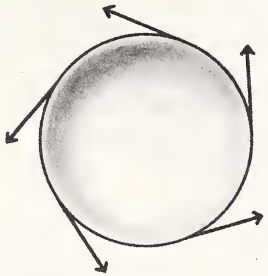
This *center* of an object is its *center of gravity*. It is the point around which the weight of the object is equally distributed. When we speak of *weight*, we are using a term which describes the pull of gravity. If a person weighs 130 pounds, we could say also that the earth is pulling on that person with a force of 130 pounds. The earth's gravitational pull is exerted on all things on the earth and on all other objects in the universe. In turn, all other objects pull on the earth. This is the reason our solar system and our universe do not fly to pieces.

But you may be thinking "Why are we not pulled into the center of the earth, or why is the earth not pulled into the sun?" This is due to the fact that every object in circular motion possesses another force. That force is centrifugal force. Or, we could say that every object tends to fly off from its circular path and move in a straight line.

You have experienced this force when the train or automobile in which you were riding moved around a curve. At every point, your body tended to move away in a straight line. If the curve was unexpected, your body may have pushed against your neighbor.

Gravitational pull and centrifugal force oppose each other. We constantly tend to be pulled toward the center of the earth and to fly off into space. Consequently, we stay *on* the earth. This seems

to be true of bodies in the solar system and the entire universe. Because sky bodies are in circular or almost circular motion, they continue to move rather than collapse toward a central point.



A flying-off-into-space motion, such as that shown in the diagram, is exerted by the centrifugal force of the rotating earth.

Bridges and buildings are built so that they are well balanced. Engineers and architects who design these structures are concerned about having weight equally distributed about the center of the object. Buildings are built with broader bases than tops so that they will not be top-heavy. The Pyramids have broad bases and narrow tops. This is true of many of our buildings. Not only do we design well-balanced buildings and bridges, but we also design well-balanced furniture, vehicles, radio and television towers, toys, glassware, lamps, and so on.

The engineers who design our modern automobiles and trains are concerned about their speed and efficiency as well as their beauty. The outside of an automobile or a locomotive is much smoother than it was a few years ago. We say that the body is streamlined.

The present smooth shape is more pleasing to the eye, and it is also more economical. When propelled by the same amount of force, a smooth, streamlined object can cut through the air to a greater distance than a non-streamlined body. This means that it will take less fuel to propel a streamlined body than a non-streamlined body. In other words, the streamlined body is more efficient. The maximum speed of trains and automobiles has been increased partly because of better fuel and better roadways, but the streamlined shapes also have helped to make possible the greater speeds.

Aircraft, boats, and ships have been streamlined, too. The shape

of an airplane is much like that of a bird, which is naturally streamlined. A bird's feathers are smooth and sleek. The feet may be drawn up out of the way when the bird is in flight. The body is so shaped that a maximum amount of movement may be obtained for the expenditure of a minimum amount of energy.

Fish, too, have naturally streamlined bodies. The shape of a submarine is much like that of a fish. Our modern ocean liners and small pleasure craft also have streamlined shapes. Aircraft, ships, and boats are built so that they cut through the air and water with as much ease as possible.

Ways of Working with Children

"About Balance and Shape" is independent of all other chapters in *Adventuring in Science*. Since the material presented involves experimenting, observing, discussing, and reading, your children will have a chance to make full use of all these ways of learning as they work through the chapter.

Study the picture on pages 162–163 of *Adventuring in Science*. Your children will want to recall the amazing feats they have seen performed at the circus. As they do this, bring out the fact that circus performers have learned to balance their bodies well. Perhaps your children will want to paint circus pictures, or they may want to produce a circus of their own. You will want to encourage them to participate in such fruitful experiences.

Borrow some blocks so that your children can experiment with building the structures pictured on page 164 of *Adventuring in Science*. Let them try to design and build other top-heavy structures. If your playground is equipped with a seesaw, experiment with it to get a feeling of balance.

Now read and discuss the material on pages 166–168. Children will want to try dropping various objects to determine whether or not they will fall at the same speeds. If the objects are heavy enough to overcome the resistance of the air fairly easily, they will fall together. Try dropping two sheets of paper of the same size; notice that they reach the floor at the same time, or nearly so. Now crumple one of the pieces into a tight ball and drop them again. This time the crumpled piece will reach the floor far more quickly. Since the ball of paper has less surface exposed to the air, it is not held back by the air as much as is the flat sheet of paper.

CHART 8 · COMPARATIVE FORCES OF GRAVITY ON SOME BODIES IN THE SOLAR SYSTEM*

Solar System Body	Weight on other bodies of a person who weighs 100 pounds on the earth	Speed at which an object must travel to escape. Does not take into account effect of an atmosphere
SUN	2,800 pounds	383 miles per second, or 1,378,800 miles per hour
MERCURY	27 pounds	2.2 miles per second, or 7,920 miles per hour
VENUS	85 pounds	6.3 miles per second, or 22,680 miles per hour
EARTH	100 pounds	7.5 miles per second, or 27,000 miles per hour
MOON	16 pounds	1.5 miles per second, or 5,400 miles per hour
MARS	38 pounds	3.1 miles per second, or 11,160 miles per hour
JUPITER	264 pounds	37 miles per second, or 133,200 miles per hour
SATURN	117 pounds	22 miles per second, or 79,200 miles per hour
URANUS	92 pounds	13 miles per second, or 46,800 miles per hour
NEPTUNE	112 pounds	14 miles per second, or 50,400 miles per hour
PLUTO	?	?

*This chart is not to be memorized. Its purpose is to present information which may be useful to you in considering questions of weight on and escape from bodies in the solar system.

Help children use their imaginations in thinking of the feats they could perform on the moon where there is relatively less gravitational pull. There a person could jump six times as high as he could on the earth. There he would use only one-sixth as much energy in lifting his foot as he does on the earth. Now think of being on Jupiter. There a person would use two and a half times as much energy in lifting his foot as on the earth. There a person could jump less than half as high as he does on the earth.

Chart 8 may be of help as you consider two questions: "How much would I weigh on another body in the solar system?" and "How fast would I have to go in a rocket to escape the pull of gravity on another body in the solar system?" Children's imaginations should not be curbed, but children should be supplied with facts

which help them reach logical conclusions. In this age of jet planes and rockets, science-fiction stories and comics, and space-travel programs on television and radio, the imaginations of children turn in these directions.

You will want to continue this kind of constructive and imaginative thinking as you read and discuss the material relating to centrifugal force, the force which opposes gravity. The earth would probably fly to pieces and all the things on the earth would fly off into space if gravity were not at work.

Some of your children will want to transfer their thinking to paper in the form of stories or pictures or both. As they do this, help them to keep in mind the facts of the situation so that their work is not purely imaginative but has a basis in fact.

Perhaps you will introduce "Problems of Builders" by visiting the site of a building in the process of construction. If it is possible, visit the same place several times so that the children may see the successive steps in a building operation. Study the pictures on pages 170–173 of *Adventuring in Science* and discuss the material presented. You will emphasize constantly the fact that buildings and bridges must be constructed so that they are well balanced.

Try the experiment with the papers described on pages 174–175 of *Adventuring in Science*, and discuss the part air plays in this experiment. Let your children construct and experiment with the paper gliders shown on these same pages. Again, you will want to emphasize the reason for the pointed-nosed glider's longer flight. Bring out the fact that streamlining an object allows it to move through the air more easily.

Some of the children in your group may have models of old and more recent automobiles, locomotives, airplanes, and ships. Encourage them to bring these models to school so that the entire group may see the way these vehicles have become more and more streamlined. Study the pictures on page 176 of *Adventuring in Science* to encourage further discussion of changes which have taken place in automobile and locomotive design.

You will want to follow similar procedures during the reading and discussion of the material concerning ships and aircraft. In studying the aircraft picture on page 178, children may wish to know about the lines hanging from the nose of the blimp. These are the "short lines" which are the first lines to be grasped by the ground crew as

the blimp is being docked. The longer lines are looped back from the nose toward the cabin. After the short lines have been grasped, the ground crew maneuvers the blimp by use of the long lines. Again, place the emphasis on the smooth, streamlined shapes which allow these vehicles to move through water and air more easily.

Materials Needed

ball
blocks, building
paper, 2 pieces same size
paper, 2 pieces 8″ × 12″ for each child
pencil, 1 for each child
ruler, 1 for each child
scissors
stones, 2 of different sizes

Think about or Do These Things

See suggestions for children, page 179, *Adventuring in Science.*

1. The ship would probably tip toward the heavier side and might capsize.
2. The lighter person will need to be at a greater distance from the seesaw support.
3. Pieces of furniture are built with broad bases.
4. If lamp bases are not broad enough, the lamps are unsteady.
5. The outstretched arms of a dancer provide balance.
6. Notice that the buildings are well balanced.
7. Help children set up a meaningful bulletin board display, or use these pictures to make a book on "Shapes of Things."
8. If there were less gravity, a person would jump much higher. If there were no gravity, he would fly off the earth.
9. To overcome the earth's gravitational pull a rocket ship would need to travel at a speed of 27,000 miles an hour. Since the moon has gravitational pull, when the rocket ship escaped the pull of the earth, it would be attracted to the moon. To escape from the moon a rocket ship would have to travel at a speed of 5400 miles an hour.

Further Activities

1. Study the shapes of automobiles parked outside your school. Go to a railroad station and study the locomotives, switch engines, and railroad cars. Discuss the shapes of these vehicles.

2. Visit an airport. Study and discuss the shape of the various airplanes.

3. Visit a harbor if possible. Study and discuss the shapes of the boats and ships.

4. Make a collection of toys. Study them to see whether they are well balanced or not.

5. Ask children to observe their younger brothers and sisters playing with blocks to see whether they are beginning to learn about balance.

6. Encourage children to design new automobiles, airplanes, trains, boats, bridges, and buildings. Discuss the balance and streamlining in each case.

Was It Worth While?

Watch individuals for evidence of progress in the use of scientific principles. Do they give evidence of understanding balance and streamlining as they apply it to new designs or observations of structures and vehicles?

You might like to draw on the board a picture of a Queer City of your own design. Make some of the buildings top-heavy; make the smokestacks wide at the top and narrow at the bottom; make some of the automobile bodies high and square; give an airplane square wings. Let children find as many things as they can in the picture which are unbalanced or non-streamlined.

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Zaffo, George J. *The Big Book of Real Boats and Ships.* Grosset & Dunlap, Inc., 1951.

Films

AIR IN ACTION. (Cor) 1 reel, b/w & color. Presents the effects of bodies moving through the air. Also shows the effect of air on stationary objects.

AIRPLANE TRIP. (EBF) 1 reel, b/w. Pictures a trip by air from Los Angeles to Salt Lake City. Servicing of the plane, as well as its instruments and operation, is explained.

AIRPLANES AND HOW THEY FLY. (YAF) 1 reel, b/w. Explains the principles of flight of aircraft. Shows various types of airplanes.

BOATS. (EBF) 1 reel, b/w. Depicts the experiences of a girl and a boy traveling by boat from Albany to New York City. Many different kinds of boats, including an ocean liner, are seen in the river.

BUILDING A HOUSE (EBF) 1 reel, b/w. Portrays the care that is used in building, step-by-step, a wood-framed, one-family house.

CIRCUS DAY. (EBF) 1 reel, b/w. Shows clowns, acrobats, and circus animals in their breath-taking feats of balance.

ELEPHANTS. (EBF) 1 reel, b/w. Shows how domesticated elephants are cared for. Shows the training of young elephants to stand on fore or hind legs, to sit on barrels, to walk planks, and to do other feats. A trained adult elephant is shown performing.

FORCE OF GRAVITY. (YAF) 1 reel, b/w. Considers the effects of gravity, beginning with the simple observation that things fall down.

NATURE'S TECHNIQUES. (ALF) 1 reel, b/w. Shows how many of man's technical achievements were inspired by living and nonliving things of the environment.

OUR OLD CAR. (TFC) 1 reel, b/w. Traces the development of automobiles from the Stanley Steamer to more modern automobiles.

PASSENGER TRAIN. (EBF) 1 reel, b/w. Describes a trip on a streamlined diesel-electric-powered passenger train leaving a large city and passing through the countryside.

PIONEER OF FLIGHT. (TFC) 1 reel, b/w. Depicts a portion of the story of the life of John Montgomery, who made the first controlled flight in a heavier-than-air craft.

Filmstrips

FRICTION AT WORK. (YAF) color.

GRAVITY. (YAF) color.

UP AND DOWN. (JH) color.

WHY THINGS FLOAT. (YAF) b/w.

IX

Wind and Water Change the Earth

Evidences of the work of water and wind are to be seen in most communities. Often these changes are made slowly, but occasionally a storm produces rapid change. In using "Wind and Water Change the Earth" you will be helping children become more sensitive to their environment and some of the changes taking place in it.

Science Meanings for Children

If you keep the following meanings in mind as you work with children, perhaps you will aid them in strengthening their understanding of the environment.

Year after year, wind and water change the earth. Wind and water wear away rocks.

Plants cause rocks to be broken into smaller rocks.

Heating and cooling may cause rocks to crack.

Animals wear away rocks by walking over them year after year.

Wind and water move the soil from place to place.

Man has been able to slow down the effect wind and water have in moving the soil.

Information for You

Perhaps you will want to read through the chapter "Wind and Water Change the Earth" rather carefully to get the feeling of the way wind and water affect rocks and soil. Weathering causes larger rocks to break into smaller ones. Erosion transports rock and soil particles from one place to another. Weathering and erosion are constantly at work.

Take a walk around your community and locate places where there is evidence of the work of wind and water. You will want to take your children to these places to note the effects of these weathering agents.

All of us are concerned about the toll erosion is taking of the soil. If there are soil reclamation projects or new dams in your com-

munity, go to the persons in charge of such projects and talk with them. Learn of the ways in which your community is at work on the problem of erosion.

Ways of Working with Children

On pages 180–181 of *Adventuring in Science* is a picture of Bryce Canyon in Utah. As you study this picture with your group you will want to bring out the fact that the weathering and erosion of the soil here has been a long, slow process. During this process, layers of soil have been exposed. Each layer with its particular mineral content has its own color. This soil cannot be used for farming or cattle raising since the fertile soil has been carried away. Bryce Canyon is beautiful to see, but it would be tragic if such effects of erosion were found all over North America.

As your children read of the work of wind and water, help them to have experiences which will make this material more vivid. For instance, rub pieces of sandstone together to make sand; use sandpaper to smooth wood; watch a sandblasting machine at work. Do the experiments on pages 182 and 184–185 of *Adventuring in Science.*

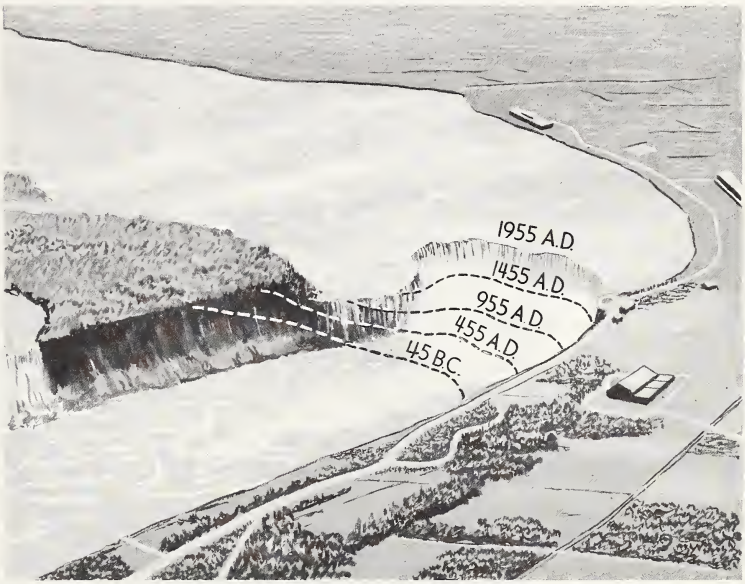
Reading about the work of wind and water will aid children in enlarging their concepts, but firsthand observation will strengthen impressions greatly. You will want to take a trip to a stream to watch the effect of water on stones and on soil. If it is possible, visit a waterfall and notice the rocks which have become loosened and have fallen over the edge of the falls. The material on page 186 of *Adventuring in Science* may be used as a basis for discussing the rate at which Niagara Falls is being worn away. Recall the fact that tons of rock fell from the United States side of Niagara Falls in 1954. This caused the falls to move upstream.

If you live near the ocean, observe the effect of pounding waves on the shore line. Study the illustration on page 191 of *Adventuring in Science* and discuss the effect of moving sand dunes on plant growth. Use photographs, slides, filmstrips, and moving pictures to aid children in clarifying their concepts.

An experiment concerning the power of growing plants is described on page 187 of *Adventuring in Science.* This has proved to be a most dramatic experience for children. When they observe the strength of growing bean seedlings, children can understand more easily how trees can split rocks apart.

Again, you will want to work through the experiment described on pages 188–189 as well as read about it. The power of expanding water as it freezes affects rocks and soil.

Ten- and eleven-year-olds are mature enough to work through the experiments described on pages 190–192. They will be able to wait for grass seeds to grow in the boxes so that their experiments may be completed. Help them to have these firsthand experiences in observing the effects of wind and water on planted and unplanted soil.



The broken lines indicate the effects of weathering and erosion as reflected in the estimated locations of the falls on the Niagara River at 500-year intervals over the past 2000 years.

Encourage children to make observations near their school and homes of the effects of wind and water. Let them share their findings with their classmates.

The first major emphasis of this chapter has been observation of the work of wind and water. The second major emphasis is the acquisition of some understanding of man's place in controlling the effects of wind and water. Seek out places in your community where control of these forces is being carried on.

If a road is under construction, what measures are being taken to hold the soil along the road banks? If sand dunes are being moved over farm land, how is the sand being controlled? If there have been

floods in your vicinity, how are the flood waters being held in check? Study the map on page 199 of *Adventuring in Science* to understand how a series of dams aids in flood control and provides recreation facilities for a great many people. If farm land in your community has eroded, what is being done to prevent further erosion? Are there evidences of erosion on the school grounds? If so, what can be done about it? These are problems which you and your group will want to work through together. You will want to consider your immediate community, as well as larger land areas, as you work with these problems.

Materials Needed

boxes, 2 wooden fruit
dishpan
electric fan, with long extension cord
flowerpot and saucer
glass, thin sheet, or cardboard, to cover flowerpot
gloves
jar, pint, with screw top
magnifying glass
newspapers, old
pitcher or fruit jar
seed, package of grass or bird seed
seeds, 10 Lima-bean or corn
soil, rich for flowerpot and average for wooden boxes
sprinkling can
stones, 2 relatively soft, e.g., sandstone
stones and soil for outdoor map

Plan to Do These Things

See suggestions for children, pages 200–201, *Adventuring in Science.*

1. If children are encouraged, they can often work out practical problems of this type.

2. When you take such a trip, make careful plans with the quarry owner to be certain that proper safety measures are taken.

3. Perhaps your group will make a similar map for your school grounds.

4. Use a magnifying glass to study this soil. Notice the absence of hard rock particles and the presence of plant debris.

5. Children can write letters asking permission to visit the dam. They might also prepare a list of questions for the person who is to be interviewed.

6. Children could make a class list or individual lists.

7. The class or individuals might keep a log for this period of time. If a limited area is chosen, they will be able to describe the effects more easily.

8. This is an interesting, worth-while project. When it is completed, invite other groups to see it.

Further Activities

1. Invite someone in your community who has colored slides of parks, such as Glacier National Park or Grand Canyon, to show them to your group. Perhaps that person or someone else has slides taken at the seashore or on a desert which can be shown.

2. Some of your children may have visited canyons or caves or beaches or deserts or mountains. Encourage them to tell of their experiences, especially to describe the soil and rocks and vegetation. Perhaps they will have pictures to share with the group.

3. Perhaps someone in your school or community has a collection of stones which have been gathered in many places. Invite that person to show and talk about his collection with the group.

Was It Worth While?

What evidence do you have that your children's concepts of change have been strengthened? Do they show some understanding of the slowness and also of the rapidness of the work of wind and water?

Do the children look at their community with new eyes? Do they see evidences of weathering and erosion which had previously gone unnoticed? You may want to ask children to make oral or written statements concerning the effects of wind and water which they had not noticed before.

Are individuals becoming better able to do research? If they are faced with a problem, are they learning to use books, people, and materials in attempting to solve their problems? Do they check the results of their research with others?

Is there evidence that the group is becoming environment-conscious? Are they aware of problems of erosion? Are they willing to make plans for erosion control and carry through those plans?

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Films

AIR IN ACTION. (Cor) 1 reel, b/w & color. (See film list for Chapter 8.)

BIRTH OF THE SOIL. (EBF) 1 reel, color. Discusses the production of topsoil, and the part played by rocks, air, sunlight, and plants in this production.

EROSION. (UW-Govt) 1 reel, b/w. Presents the story of man in relation to erosion. Emphasizes the fact that destructive erosion is unnecessary.

GRASSLAND. (UW-Govt) 1 reel, b/w. Emphasizes the problem of soil conservation on the grazing lands of the arid southwestern United States. Shows how over-grazing of land may be curtailed.

HARVEST FOR TOMORROW. (UW-Govt) 2 reels, b/w. Considers the need for soil conservation and sound pasture-improvement program in rural New England. Shows soil-building practices in this area.

THE MIGHTY COLUMBIA RIVER. (Cor) 1 reel, b/w & color. Shows the Bonneville and Grand Coulee dams and the part they play in power development. The salmon industry and irrigation are emphasized.

SOLIDS, LIQUIDS, AND GASES. (See film list for Chapter 2.)

UNDERSTANDING OUR EARTH: GLACIERS. (See film list for Chapter 5.)

UNDERSTANDING OUR EARTH: SOIL. (Cor) 1 reel, b/w & color. Shows how soil is formed from rock particles and decaying material. The types of soil throughout the United States and the importance of soil conservation are emphasized.

WATER CYCLE. (See film list for Chapter 2.)

WATER FOR DRY LAND. (UW-Educ) 1½ reels, b/w. Shows how desert land can be transformed to productive farm land by controlling the water supply.

WEARING AWAY OF THE LAND. (EBF) 1 reel, b/w. Considers the wearing away of the land in one place and its deposit in another place on the earth. Emphasizes the fact that soil is not lost but that it is transferred.

WHAT MAKES A DESERT? (YAF) 1 reel, b/w. Describes factors causing a desert, with special reference to deserts of the southwestern United States.

WHAT MAKES RAIN? (See film list for Chapter 2.)

WORK OF RUNNING WATER. (EBF) 1 reel, b/w. Considers the way in which rocks and soil are worn away by the constant effects of running water.

Filmstrips

CHANGING SURFACE OF THE EARTH. (YAF) color.

CONSERVING WATER AND SOIL. (PDP) b/w.

OUR EARTH IS CHANGING. (JH) b/w.

THE SOIL. (JH) b/w.

SOIL AND ITS USES. (EGF) color.

SOIL CONSERVATION SET. (SVE) 4 filmstrips, color: HOW NATURE DEFENDS SOIL; HOW MAN DESTROYS SOIL; CONTROLLING EROSION IN FIELDS AND WOODS; GULLY EROSION PROBLEMS.

X

Electricity All about Us

Sometimes the curiosity of children concerning electricity leads them to perform dangerous experiments with house current. "Electricity All about Us" offers an opportunity for children to experiment with electricity safely. It also provides an opportunity to understand further another form of energy which man has learned to use. Both girls and boys will be interested in performing the suggested experiments, so you will want to provide opportunities for individual and small-group activities.

Science Meanings for Children

Again, some of your children will have had more experiences with electricity than others. Yet, all will gain new learnings or enlarge previous learnings as they work with the material presented in "Electricity All about Us."

Some of the meanings emphasized in this chapter are as follows:

Lightning is electricity. Some electricity is caused by rubbing.

Thunder and the sound of sparks are caused by the expansion of heated air.

Frictional electricity is different from magnetism.

We can protect ourselves from lightning.

Electricity produces heat and light.

When a circuit is complete, electricity can move through the circuit. Some ways of wiring an electric circuit are better than others.

Electricity can be used to send messages. Electricity can cause a doorbell to ring.

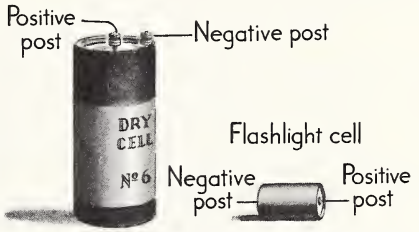
Information for You

It is unwise to allow children to experiment with electricity using the wiring system of your building, since they might receive shocks. However, there is no danger in experimenting with dry cells. You may want to complete the circuits suggested in the chap-

ter "Electricity All about Us" before working them out with your children so that you will feel more familiar with the principles involved.

Dry cells have two connecting posts, or terminals. The center terminal is called the positive post; the terminal connected to the zinc can is called the negative post. A flashlight dry cell also has two posts. The positive terminal is at the center of one end; the entire zinc can or any portion of it acts as the negative terminal.

You will find that a complete circuit must be made before electricity will flow in it. Be sure that all connections are tight, that if light bulbs are used they are screwed tightly into sockets, that



insulation is scraped off where wires are connected, and that the switch is pressed down firmly. You will want to study the pictures in *Adventuring in Science* on pages 212, 214–215, and 220–223 to understand how some complete circuits can be formed.

Electricity is produced in three ways: by rubbing certain materials together, by the use of chemicals, and by generators. Electricity produced by rubbing is called frictional or static electricity. The chemicals in a dry cell or a storage battery also produce electricity. Generators produce the current electricity for our homes, offices, and schools, as well as for machinery, electricity-powered trains, and many other devices using electric motors.

When we comb our hair or walk over a wool rug on a dry day, electricity is produced by rubbing or friction. Sometimes we get a shock from this electricity as it leaves our bodies. The electricity leaves the body when the body comes in contact with a good conductor, such as metal or another person.

A great deal of frictional electricity is produced in clouds during thunderstorms. This electricity is discharged from one part of a cloud to another part of that same cloud, from one cloud to another, or from a cloud to the earth. In order to protect ourselves from

lightning, we try to put our bodies in a position where they will not be a part of a good electrical circuit through which lightning can pass.

Frictional electricity is quite different from magnetism. Magnets will attract objects made of iron or steel, but objects charged with frictional electricity will not. Electrified objects will pick up lightweight nonconductors of electricity. Objects which are chosen to be electrified by rubbing should be nonconductors of electricity such as combs and fountain pens. If you should try to electrify an iron rod or a silver spoon by rubbing it, any electricity produced would pass into your hand. The electricity would not remain on the rod or spoon.

Whenever electricity passes through wires, heat is produced. The more resistant the wire, the more heat is produced. Wires in toasters, electric irons, electric heaters, electric blankets, and other appliances of this kind are resistant to electricity and become heated. Sometimes the wire becomes so hot that it glows. This principle is used in making electric light bulbs. Here the filament is made of a metal known as tungsten. Tungsten can withstand a great deal of heat before melting; therefore it is particularly useful for producing light.

Ways of Working with Children

You may want to use the pictures on pages 202–203 of *Adventuring in Science* as motivating material for "Electricity All about Us." As your children study this picture, perhaps you will ask them to find as many evidences of electricity as possible. Perhaps there will be natural motivation for the study of this chapter on a dry day when writing paper clings to sleeves or when hair snaps and crackles as it is combed. You may wish to introduce the material on current electricity before working with frictional electricity. If so, try placing a dry cell, insulated wire, a switch, a flashlight bulb, a socket, a knife, and a screwdriver on a table. Ask the children to see if they can make the bulb light. A discussion of complete circuits will follow naturally.

You will want to make provisions for individual as well as group experimenting. If class experimenting and committee demonstrating are done, be sure to allow time for individuals to repeat the experiments or work out new ones. Girls should be helped to feel com-

fortable in working with these materials. Our culture often makes it seem "unladylike" for girls to be interested in electricity, but they will enjoy working out electric circuits if they are encouraged. Only when individuals work in these ways can you be sure that each child has an opportunity to understand fully.

Help children to work out the experiences pictured on pages 204–205 of *Adventuring in Science*. Here the girl electrified her comb by pulling it through her hair. Then the comb was held close to bits of tissue paper, and the paper was attracted to the comb. The boy rubbed a piece of paper with the sleeve of his woolen sweater and the paper was attracted to the wall. Read and *discuss* this material with your children. They will offer many additional examples of frictional electricity.

Children will ask why these things occur. You will want to discourage any belief that they are magical. A very simple explanation, such as the following, might be used:

Scientists believe that all things are made of very tiny particles called molecules. Scattered among these molecules are even smaller particles known as electric charges. Negative electric charges are called electrons; positive electric charges are called protons. It is thought that electrons are rubbed off the hair on to the comb. Now the comb has a surplus of electrons and we say that it is electrified. The comb will now attract bits of paper to which some of the electrons move. When a bit of paper has received some electrons, it falls away from the comb because objects which are electrified in the same way do not attract one another.

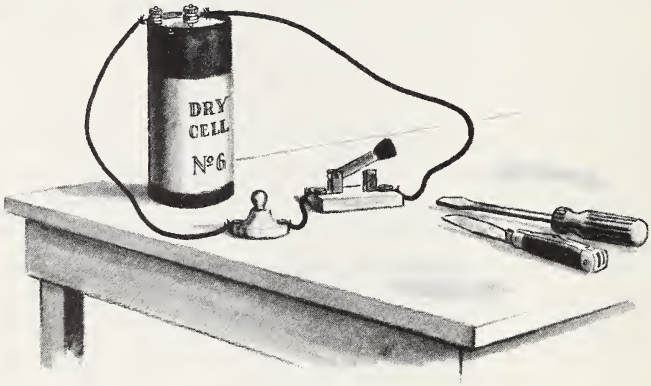
It is thought that when the boy rubs his woolen sweater over a larger piece of paper, electrons move from the wool to the paper so that the paper becomes electrified. The paper will stick to the wall until enough electrons have moved from the paper to the wall. Then the paper will fall away from the wall.

After walking over a wool rug, we may receive a shock if we touch metal or another person. The shock occurs as a stream of electrons leaves our body and moves into the conductor. If the electrons leave our body through one point, such as a finger tip, we feel a greater shock than if they leave through the entire surface of the hand.

Magnetism and frictional electricity are quite different. Help children to understand this by working out the experiences suggested

on pages 207–209 of *Adventuring in Science*. They will see that electricity is conducted by water, metals, and people. They will understand also that magnetism is not conducted by these things.

Frictional electricity can be produced by rubbing a piece of glass with silk, as described on page 209. When this is done, it is thought that electrons move from the glass to the silk. This leaves the glass with an excess of protons, and we say that the glass is positively charged. Bits of paper are attracted to this positively charged glass. When enough electrons have moved from the bits of paper to the glass, the pieces of paper fall away.



The completed circuit includes dry cell, insulated wires, bulb, socket, and switch.

Again, as in the case of the comb, rubbing balloons with wool causes them to have a surplus of electrons. When this occurs, the balloons repel each other. If a negatively charged comb is brought near the balloons, the comb will repel the balloons.

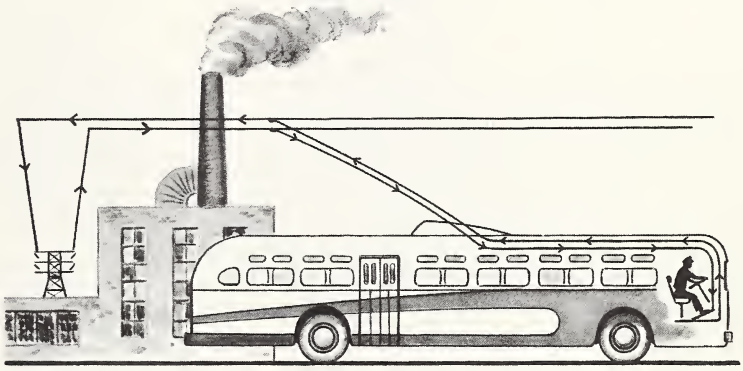
Objects which are electrified in the same way repel each other. But objects which are electrified differently attract each other. Also, an electrified object and a neutral object attract each other.

Children should not be frightened by lightning, but they should know how to protect themselves from it. In general, the best rule is never to be the best conductor for lightning in the immediate vicinity. This is why one should never stay out on an open playing field or in swimming during a thunderstorm. Our bodies are excellent conductors of electricity. If we expose ourselves in this manner, lightning may find a path through us and into the ground.

Do the experiments suggested on pages 212–215 of *Adventuring in Science* in order to help children understand that electricity causes

heat and light. In a home it is important to keep electricity where you want it to be. Therefore, wires through which electricity flows are covered with nonconducting materials, or insulation, so the electricity will stay where it is supposed to stay. Since the bare hot wires of an electric circuit can cause fires, all circuits should be kept in good repair.

Through working with light bulbs, switches, wires, and dry cells children come to understand more about electricity and how we use it. Help children trace electric circuits through flashlights and in a



The complete circuit of an electric trolley extends from the generating station, through overhead wires, to the bus, and back to the station.

trolley bus. Lead children to be aware of the great importance electricity assumes in modern living. Lead them in a discussion of the ways electricity is used in sending messages.

Doorbells also use electricity. Help children to work out the doorbell circuits suggested on pages 220–221 of *Adventuring in Science*.

When children are connecting two lights in a circuit, the most natural way to do this is shown on page 222. This is known as a *series circuit*, since a series of objects is connected together. The disadvantages of the series circuit are that the bulbs burn dimly and that one bulb cannot be removed so as to leave the second bulb lighted.

A *parallel circuit* is shown on page 223. Notice that the same materials are used. The only difference is in the wiring. Electricity can now travel through either of the bulbs without moving through the other bulb first.

Encourage children to make practical use of their electricity material. Someone may want to wire a model ship or airplane. Perhaps others will want to wire the museum shelves or help younger children with their wiring problems.

Materials Needed

balloons, 2
bulb, burned-out electric
bulbs, 2 or 3 (1.5 volt), flashlight
cloth, woolen
comb, 1 for each child experimenting
doorbell, electric
dry cells, 2 or 3, No. 6
flashlight
glass, 6″ × 8″, approximately
knife, paring
magnet, horseshoe or U-shaped
magnets, pair of bar
mirror, pocket
nail, large for electromagnet
paper, bits of tissue
paper, 3 or 4 sheets, typing
paper clips
screwdriver
silk, 8-inch square, approximately
sockets, 2 porcelain, for flashlight bulbs
switches, knife and push-button
tape, 3 feet, electric insulation
thread, spool
thumbtacks
wire, 10 feet, insulated copper bell
wire, 2 feet, multiple-strand iron picture

This Is for You

See suggestions for children, pages 224–225, *Adventuring in Science.*

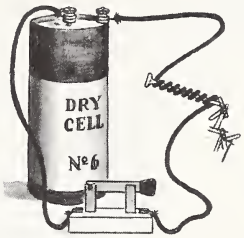
1. Caution children against attempting to repeat this experiment.

2. North-seeking ends of magnets repel each other; south-seeking ends repel each other; but north-seeking and south-seeking ends attract each other.

3. An electromagnet may be made by winding a length of insulated copper wire around an iron bolt or a large nail and attaching the ends of the wire to a dry cell. If an additional small length of wire is used, a switch may be put into the circuit also. When electricity is moving in the circuit, the nail is quite highly magnetized. Test this by bringing the electromagnet near a pile of paper clips.

When the flow of electricity is stopped by lifting the switch or

disconnecting one of the wires, the bolt loses much of its magnetism. Electricity moving in a circuit acts like a magnet.



4. Connect the dry cell to the light or bell, but leave a gap somewhere in the circuit. Place the material to be tested across this gap. Metals, very salty water, and water with quite a lot of lemon juice are conductors of electricity. Dry cloth, wood, cotton, plastic, rubber, and glass are nonconductors, or insulators.

5. Sometimes blueprints of the school wiring system are available. Children are interested in seeing such blueprints.

6. The materials needed are a dry cell, a switch, an electric bell, a knife, a screwdriver, enough insulated copper bell wire to reach to the basement and back. If this is quite a distance, two dry cells may be needed to furnish enough electricity for the circuit.

7. Perhaps the custodian will act as a resource person here.

8. Children may want to write a story on this theme or prepare a bulletin board illustrating it.

9. Arrange for this trip well in advance. Then your group will have an opportunity to locate and study pictures of generators before seeing them in operation.

Further Activities

1. Visit a telegraph office and watch the sending and receiving of messages. Children may enjoy learning the Morse code for their initials or name as a result of this visit.

2. Visit a telephone office. Notice the complicated wiring that is necessary.

3. Find out if there is a large commercial electromagnet in use near you. If so, visit the place and watch the electromagnet in action.

International Morse code

A	•–	N	–•
B	–•••	O	–––
C	–•–•	P	•––•
D	–••	Q	––•–
E	•	R	•–•
F	••–•	S	•••
G	––•	T	–
H	••••	U	••–
I	••	V	•••–
J	•–––	W	•––
K	–•–	X	–••–
L	•–••	Y	–•––
M	––	Z	––••

4. A storage battery is used in an automobile. Perhaps one child or a group of children would like to find out more about a storage battery and report the findings to the class.

5. Thomas A. Edison, Alexander G. Bell, Samuel F. B. Morse, Hans C. Oersted, and Michael Faraday are men who experimented with electricity in various ways. Ask for volunteers who will find out about the work of these men and report it to the class.

6. Find directions for a homemade telegraph set and encourage some of your children to make one.

7. Allow children to arrange pictures on the bulletin board showing ways in which man uses electricity. Perhaps they will group their pictures under such titles as "Electricity for Light," "Electricity Helps Us Do Work," "Electricity for Travel," "Electricity for Pleasure."

8. Children often think that electricity can be seen. In order to show them that it cannot, open a flashlight dry cell which is still usable. The black paste in the dry cell is usually a mixture of the following chemicals: ammonium chloride, manganese dioxide, zinc chloride, coke, and graphite. The can is made of zinc and the central pole of carbon. None of these materials is harmful to the hands.

Was It Worth While?

One way to evaluate learnings is to ask children to perform experiments, some of which might be:

1. Wire a bell so that it will ring.
2. Wire a light bulb so that it will light.
3. Take a flashlight apart and put it together correctly.
4. Wire two lights in a circuit so that one can be unscrewed without the other going off.
5. Electrify a comb. Show what materials it will and will not attract.

Or, you may wish to ask children to make drawings to illustrate specific learnings. You may want to ask them to:

1. Draw a light bulb. Show the path of electricity through the bulb.
2. Draw a dry cell. Label all the parts you know.

Warren W. McSpadden

Completing an experience successfully gives children a sense of pleasure and achievement.

3. Draw a complete electric circuit. Label the parts in your circuit.

Perhaps you will want children to write down all the ways they can think of that man uses electricity. Perhaps you will ask them to write rules for safety in a thunderstorm.

Since the materials of this chapter lend themselves so well to individual and small-group experimenting, do as much of this as possible. Encourage all the children to work with materials. See to it that a few do not monopolize the science table. Watch for signs of individual progress in initiative, in responsibility, and in cooperation.

As you discuss man's use of electricity, is there evidence of ap-

preciating his ability to control and make use of this type of energy? Do children have a better idea of the technical knowledge an electrician or an electrical engineer must possess? Do they begin to appreciate the place of electricity in the lives of all of us?

Has some of the content of this chapter been translated into action? For example, do children know what to do during a thunderstorm, and, even more important, do they act on their knowledge? Do children have a healthy respect for the house electric circuit? Are they careful when using electrical appliances? Again, you will want to help children increase their ability to put content into action. Determining this ability is an important phase of the total program of evaluation.

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Films

ELECTROMAGNETS. (YAF) 1 reel, b/w. Shows how to build a simple electromagnet from home materials.

FLOW OF ELECTRICITY. (YAF) 1 reel, b/w. Describes, through the use of simple materials and animated drawings, the movement of electricity in a complete circuit.

HOW MAN MADE DAY. (Cor) 1 reel, b/w & color. Traces the development of illumination from primitive to modern times.

INTRODUCTION TO ELECTRICITY. (Cor) 1 reel, b/w & color. Considers static electricity through experiments with a comb. Shows how electricity is used in a flashlight.

MAGNETS. (YAF) $1\frac{1}{4}$ reels, b/w. Considers the nature of magnetism and the behavior of magnets. Discusses temporary and permanent magnets as well as the principles of polarity.

MAGNETISM. (Cor) 1 reel, b/w & color. Explains how magnetism differs from electricity. Shows permanent and temporary electromagnets, how to make magnets, magnetic fields of force, and uses of magnets.

MAKING ELECTRICITY. (EBF) 1 reel, b/w. Shows the making of a miniature generator in the laboratory. Then shows how a large hydroelectric power plant produces and distributes electricity.

STORY OF ELECTRICITY. (Knowledge Bldrs) 1 reel, b/w. Describes the early use of the magnet for navigation. Shows some of the historical development of man's use of electricity, including the work of Morse, Edison, and others.

TELEVISION: HOW IT WORKS. (Cor) 1 reel, b/w & color. Takes us behind the scenes to watch the production of a TV program.

THUNDER AND LIGHTNING. (See film list for Chapter 3.)

Filmstrips

ELECTRICITY. (SVE) b/w.

ELECTRICITY. (YAF) b/w.

FRICTIONAL ELECTRICITY. (YAF) b/w.

HOW WATER POWER PRODUCES ELECTRICITY. (PDP) b/w.

LIGHT IN OUR DAILY LIVES. (EGF) color.

MAGNETS. (YAF) b/w.

THE WONDER OF THE ELECTRIC LIGHT. (EGF) color.

THE WONDER OF THE TELEGRAPH. (EGF) color.

THE WONDER OF THE WIRELESS. (EGF) color.

XI

Animals Live Together

Children are often surprised to learn that many animals live social lives. Some animals live in a very complex social organization while others seem to live alone in the community.
Although we are aware of the social lives of many animals and compare them with man's social existence, care should be taken to help children understand the fundamental difference between them. Man is capable of thinking. His co-operation, his responsibility, his initiative, his adaptability are based upon thinking and reasoning. No other animal has the power to reason. The actions of other animals are based upon instinct.

Science Meanings for Children

The understandings children have concerning animals depend upon the experiences they have had. Some children own and care for pets, while others have never had this experience. Some children live in a rural or suburban community or have visited there, while others are familiar with city streets only.

Therefore, as your children study about the animals presented in "Animals Live Together" some of the following meanings may be new to them; others may be somewhat familiar but need to be strengthened.

Many kinds of animals live in a community.

Some animals live together in a social organization; others live alone within a community.

There are advantages and disadvantages in social living.

Some of the common insects lead complex social lives.

Information for You

Animals seen together are not always members of a social group. May flies, butterflies, turtles, frogs, and alligators are examples of such animals. Hundreds of May flies, dragonflies, or butterflies may be seen together over a field, yet they do not form a swarm. They all just happened to hatch about the same time in the same

vicinity, and have the same few days of life span. Frogs sit in the tall grass along the river bank. As you walk past, many of them jump into the water or away through the grass. But the frogs were together only by accident. The same thing is true of turtles which just happen to take advantage of the same sunny log all day.

Some animals live solitary lives most of the time. There are solitary bees, solitary wasps, and solitary spiders.

On the other hand, some animals live in groups all or part of the time. This method of living has certain advantages. For example, prairie dogs living in groups are close enough together to hear "barks" of alarm given by other prairie dogs. Some birds and other animals get food more easily because they are in groups. On the other hand, when there is a larger group a greater quantity of food is needed.

Some animals live in herds for most of the year. They live together during the mating season and long enough to raise their young. Deer, bison, sheep, mountain goats, elephants, wolves, cows, and horses are herd animals.

Deer are given some protection by herding together. A herd of deer can kill a wolf, but rarely could one deer do so alone. Herds of sheep, goats, bison, and elephants are better protected from their enemies than single animals would be.

Some animals, such as chickens, turkeys, and partridges, band together at night to sleep. Again, the cry of one alarmed bird warns the entire flock.

Other animals hunt together. Lions often band together to hunt. Wolves hunt in packs. Birds seek food in large flocks.

Many of our common birds migrate in flocks. Salmon and shad migrate up fresh water streams to spawn, and eels migrate down the streams and to the Caribbean to spawn. Whales migrate to deep water to bear their young. Seals, walruses, and sea lions migrate to certain spots to raise their young.

Other animals always lead social lives. For example, honeybees lead a successful social existence. There are three kinds of bees in a hive: a queen, several drones, and thousands of workers. The queen lays eggs. One of the drones mates with the queen and fertilizes the eggs. Workers make wax cells, gather pollen and nectar and store them in the cells, care for the young bees, protect the queen, clean the hive, and do all the other necessary work.

Each bee works by instinct. It does the same job in exactly the same way that all other bees before it have functioned in that particular job. When the new queen hatches, the old queen leaves the hive with part of the swarm. In this way new honeybee families are founded.

Ants live an equally complex social existence. They resemble a honeybee family in many ways. There are female, male, and worker ants. The workers are wingless, and do the same kinds of jobs that are done by worker bees. Queen and male ants perform the same function for the anthill as queen and drone bees perform for the beehive.

Ways of Working with Children

The material in the chapter "Animals Live Together" is intended to encourage careful observations of animals and a discussion and checking of those observations. The picture and text on pages 226–229 of *Adventuring in Science* may give you suggestions for a valuable outdoor experience. Take children outside during various seasons of the year to listen for animal sounds and to observe animals in their natural environments.

Leisurely walks, when children have time to watch and think and talk about things that interest them, are far more worth while than hurried trips. Try not to rush children. Taking time pays large dividends. Do try taking excursions near your school and see for yourself how stimulating they are to thinking and discussion. Also, you can observe the out-of-doors from your classroom window. Notice which animals can be seen and how they behave.

As you observe animals in your community, bring out the idea that these animals find food, water, warmth, and protection in this community. Help children to understand that the physical features of the community influence the kinds of animals found there. Use the picture on pages 226–227 and the picture on the title page of *Adventuring in Science* as a basis for discussion. Find pictures of animals in quite different environments and use those pictures as a basis for discussing such points as: What animals live here? What is the weather like in the winter and summer? What food and shelter would the animals find?

In your observations and discussions, lead children to understand that some animals are solitary. Use the material on pages 230–233

of *Adventuring in Science* to emphasize this meaning. Encourage your children to find other animals which lead solitary lives most of the time.

Careful observation of the social habits of the animals found in your region can be fostered. Lead children to watch carefully to find out whether the animals live together all or part of the time. Help them to observe to see if they can find out why certain animals live together. Do the children know whether the animals living in a particular environment feed on other animals living there as is true of the pelicans shown on page 235 and the starfish shown on page 236 of *Adventuring in Science*? The red-backed sandpiper shown in the latter picture does not feed on the oysters, but it does feed on other small animals found in the sand. Encourage children to check their observations with authoritative sources. Following are questions which may guide them in their observations and in the use of source material.

Do other animals live in herds part or all of their lives as do the Indian elephants shown on page 238 and the African elephants shown on page 158? What are the advantages of living in herds? Are there disadvantages?

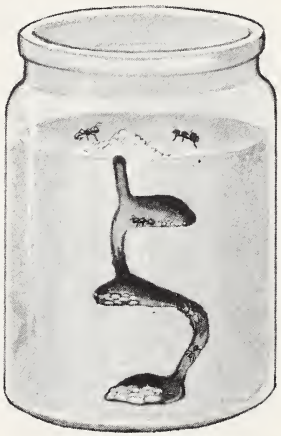
Do some animals hunt food together? Do some band together for sleeping? Are some found feeding near one another because food is available for all in that particular place? The birds shown feeding together on page 241 do not move about in flocks, but they feed near one another because ample food is available. In this picture two birds are feeding on the ground. The one in the distance on the ground is a blue jay; the one in the foreground is a sparrow. On the tree to the left is a hairy woodpecker; on the tree to the right is a brown creeper; on the tree branch in the center is a white-breasted nuthatch.

Do some animals come together for migrating as do the male and female mallard ducks shown on page 242 and the Canada geese shown on the title page? Keeping a record of birds seen in your community in the fall, winter, and spring will further children's understanding that some birds are winter residents, some are summer residents, and some are year-round residents. Discuss the food needs of these birds. Discover where the birds spend other parts of the year.

Animals other than birds migrate also. Fishermen, such as the

shad fishermen shown at work in a boat on the Hudson River on page 244 of *Adventuring in Science,* know of the migratory habits of fish and take advantage of these habits in their trade.

Working with this chapter offers you an opportunity to observe social animals. Perhaps you can visit an apiary where bees are kept. Ask the keeper of the apiary to talk to your children about beekeeping. He will be able to tell many interesting facts, such as that drone and worker bees may live only one or two months, while queen bees live for several years. Ask the beekeeper to show the children the equipment he wears while working with his bees. Help children to see that bees are kept near orchards of fruit trees or fields of clover or buckwheat so that a plentiful food supply will be available.



Ant eggs, larvae, and pupae are shown on different levels of the tunnel.

Perhaps your group can stand around an anthill and watch busy ants at work. You can dig up a colony of ants and put them into a mason jar. Dig at least a foot deep so that you will be likely to include the queen, since the colony will not work without a queen. Set the jar in a pan of water so the ants will not escape. Keep dark paper around the jar for a few days, then remove it and observe the tunnels made along the inside of the jar. Watch the ants work in these tunnels. Feed the ants a few grains of sugar and a few bread crumbs each week. After the children have had time to study the ants, return them to their natural environment.

After observing ants and bees closely, children will read the material concerning them with much more interest and understanding.

They will want to observe further in order to search for evidence of what they have read.

The chapter "Animals Live Together" offers you an opportunity to make extensive use of the bulletin board as an aid to further exploration. Perhaps you will want to place along the top of a large bulletin board space such signs as these:

ANIMALS THAT LIVE ALONE
ANIMALS THAT LIVE IN GROUPS
ANIMALS THAT MIGRATE IN GROUPS
ANIMALS THAT FEED TOGETHER
ANIMALS THAT CARE FOR THEIR YOUNG TOGETHER
ANIMALS THAT BAND TOGETHER FOR SLEEPING

Then you will encourage children to supply pictures which will illustrate these ways of living. Perhaps you will furnish some pictures, but not too many. If *you* supply all the pictures, children will soon lose their incentive to search and will be hindered in working through a project co-operatively.

Give children suggestions for sources of pictures, such as old magazines, old books, newspapers, Audubon Society bird pictures, sets of animal pictures, and so on. Guard against the mutilation of books or magazines that are on file at home or at school.

Children should be encouraged to exhibit their pictures in an attractive manner. Artistic arrangement of bulletin boards is important. You will not be successful in this work unless times are set aside when children are afforded opportunities to arrange and enjoy their materials. The pictures that are exhibited should be studied carefully.

Questions such as "Why do you suppose these ducks migrate?" or "What does this picture show about the social habits of sheep?" lead children to think, to observe, and to seek books for information. Some children will become intensely interested in the life story of a given animal. They will seek information concerning it in their science books, children's encyclopedias, and other reference books and magazines.

The children's work with books will give you an opportunity to teach children how to use tables of contents, indices, and encyclopedias. They will want to learn these techniques so that they may have the tools with which to proceed independently in their research. Do help children to learn how to use these tools effectively.

It is best to observe a real animal in its habitat in order to learn about its habits. Certainly, pictures of animals should not be allowed to interfere with firsthand observation. But many interesting animals can be studied only through pictures. Use the pictures in *Adventuring in Science* and other printed sources for careful study and discussion.

Materials Needed

None, other than those which are readily available in the local environment.

Finding More about Social Animals

Worker termite

See suggestions for children, page 253, *Adventuring in Science.*

1. Useful books are:

Henderson, Luis M. *Amik: The Life Story of a Beaver.* William Morrow and Company, Inc., 1948.

Lathrop, Dorothy P. *Let Them Live.* The Macmillan Company, 1951.

2. Concrete and concrete block foundations are not attacked by termites.

Think about These Things

See suggestions for children, page 253, *Adventuring in Science.*

1. Poison is used on grasshoppers when they are destroying crops.

2. These animals care for their young until they are strong enough to find their own food. At first they feed on milk from the mother's body. Later they eat meat brought to them by their parents.

3. These animals feed on smaller animals and small plants in the ocean water. As the ships move through the water, a constant fresh supply of food is at hand. As the tide moves in and out, fresh food is brought to barnacles fastened to a dock.

Do These Things

The purpose of these activities suggested on page 253 of *Adventuring in Science* is to compare communities. You may find quite different communities, such as a water and a meadow community, in your own environment.

Further Activities

1. Encourage family excursions to see animals in their native habitats.

2. If you are near a zoo, a trip to see how the animals live there would be helpful. Children should be led to compare the lives of animals in the zoo and in their natural habitats.

3. Find out if there is a bird or wildlife sanctuary or a fish hatchery near you. Visit such places to observe the animals.

4. Encourage individuals to select an animal for study. Let the child do research reading about the animal chosen and make a report to the class.

5. Ask children to report on such topics as: Where do mallard ducks (or some other native bird) spend other parts of the year? Why do animals migrate? Why do animals hibernate? What are the advantages and disadvantages to animals in social living? What are the advantages and disadvantages to them in solitary living?

6. Select an animal story you think your children will enjoy and read it to them.

Was It Worth While?

Perhaps you will ask children to write about or discuss such questions as the following:

1. What is the work of various members of a beehive?
2. What are some advantages in social living? in solitary living?
3. Does a solitary animal do work?
4. What are some reasons for animals living together in groups for short periods of time?
5. What is the difference between turtles seen together on a sunny log and a herd of deer?
6. What are some animals that live in your community? Choose a different community and tell which animals might be found there and why.
7. Compare a human community with that of beavers, or bees, or ants, or prairie dogs.

You will want to determine whether this experience has been worth while in other ways also, since you will value changes in behavior above minute fact-gathering. These questions may guide you in looking for behavior changes:

1. Have the attitudes of individuals toward other members of the group been affected? If so, how and why?

2. Is there evidence of more accurate observation on the part of the children?

3. Are the children using source material more intelligently?

4. Is there evidence that they are making use of their previous learnings as they attack new problems?

5. Are the children better able to pursue independent interests both inside and outside the school situation?

6. Am I becoming increasingly aware of the abilities and needs of individuals in my group?

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Films

ANT CITY. (ALF) 1 reel, b/w. Visualizes the complex society of a colony of ants.

ANTS. (EBF) 1 reel, b/w. Shows detailed description of the life cycle of the carpenter ant. Shows the activities and nests of mound-builder, black, household, and carpenter ants.

BEACH AND SEA ANIMALS. (See film list for Chapter 5.)

BEE CITY. (ALF) 1 reel, b/w. Observes the thirty thousand members of a hive of bees.

BIRDS OF THE DOORYARD. (See film list for Chapter 7.)

BIRDS OF THE WOODLANDS. (See film list for Chapter 7.)

COMMON ANIMALS OF THE WOODS. (See film list for Chapter 5.)

ELEPHANTS. (See film list for Chapter 8.)

FARM ANIMALS. (See film list for Chapter 5.)

HIGH OVER THE BORDERS. (NY Zool) $1\frac{1}{2}$ reels, b/w. Presents the story of birds making their annual round-trip migrations from North America to South America.

HONEY BEE. (EBF) 1 reel, b/w. Describes the life cycles of worker, queen, and drone honeybees. Emphasizes the roles of workers, queens, and drones.

JUNGLE GIANTS. (See film list for Chapter 5.)

KANGAROO RAT. (Barr) 1 reel, b/w. Pictures the digging of a burrow and the interior of the burrow. Some social relationships are shown.

LIFE OF AN ANT. (Commonwealth) 1 reel, b/w. Describes the complete life history of an ant. Shows ants building and defending homes, hunting food, and caring for young.

MAMMALS OF THE COUNTRYSIDE. (See film list for Chapter 5.)

MAMMALS OF THE ROCKY MOUNTAINS. (See film list for Chapter 5.)

MAMMALS OF THE WESTERN PLAINS. (See film list for Chapter 5.)

PIRATES OF THE DEEP. (Bray) 1 reel, b/w. Shows the ways the sea animals get their food. Shows starfish attacking clams and scallops.

POND INSECTS. (See film list for Chapter 7.)

THE RED-WINGED BLACKBIRD. (See film list for Chapter 7.)

SALT WATER WONDERLAND. (Sterling) 1 reel, b/w. Pictures marine life around a coral reef. Coral polyps, octopi, barracuda, and porpoises are shown.

THE SEASHORE. (See film list for Chapter 1.)

SEASHORE WONDERLAND. (Holst) 1 reel, color. Sea-dwelling animals along the coast of Southern California are shown. Included in this study of sea life are the sea anemone, nudibranch, snail, starfish, hermit crab, sea cucumber, sea urchin, and octopus.

SPIDERS. (EBF) 1 reel, b/w. Tells the life story of the nursery-web spider. Also shows unique characteristics of orb-web, funnel-web, and trap-door spiders.

SWAMPLAND. (Library Flms) 1 reel, b/w. Shows how animals live in swampland communities in the United States.

WATER BIRDS. (EBF) 1 reel, b/w. Shows several birds adapted to living in a shore environment. The brown pelican, egret, mallard duck, and Canada goose are shown. The migration route of the Canada goose is described by means of animated drawings.

WILD ANIMALS—THEIR HOMES AND HABITS. (See film list for Chapter 7.)

WILD LIFE ON THE DESERT. (See film list for Chapter 5.)

WILDLIFE OF THE SIERRA NEVADA. (Audubon) 1 reel, color. Shows birds and small mammals of the Sierra Nevada in their native habitats. Emphasizes the value of observation of wildlife.

WONDERS IN THE DESERT. (See film list for Chapter 7.)

WONDERS IN YOUR OWN BACKYARD. (Churchill-Wexler) 1 reel, b/w. A girl and a boy find several animals living in a back-yard community, including a snail, sow bug, worm, spider, and millipede.

Filmstrips

INSECT COMMUNITIES. (Curr F) color.

LIFE IN PONDS, LAKES, and STREAMS. (JH) color.

LIFE OF THE HONEYBEE. (SVE) color.

PLANTS AND STRANGE ANIMALS OF THE SEA. (JH) color.

SHELLFISH OF THE SEASHORE. (JH) color.

SMALL FRESH-WATER ANIMALS AND INSECTS. (JH) color.

XII

We Live and Work Together

One of the goals of teachers in the elementary school is to help children live and work together more effectively. Some children of ten and eleven have deep fears concerning their eventual height and weight which prevent them from living with others as well as they might. "We Live and Work Together" presents material which answers some of the questions children have concerning body growth in the belief that a feeling of security fosters progress in a child's ability to work with others.

Man is a mammal, but he is different from all other mammals in that he is able to think and plan. People, like all animals, are dependent on green plants and other animals for food. People need warmth, sunlight, food, and water for proper growth. Because people can plan, they can accomplish many things. They can plan for the protection of plants and animals. They can plan for new types of plants and animals. They can plan for proper food and healthful places in which to live. Most important of all, they can plan to live well together.

Science Meanings for Children

It might be well to observe and talk with your children in an attempt to determine whether or not they need special help in relation to one or more of the following meanings:

Our bodies change as they grow. Proper food is important for good body growth.

Man is the only living thing which is able to think and plan.

We can make plans for the protection and improvement of plants and animals.

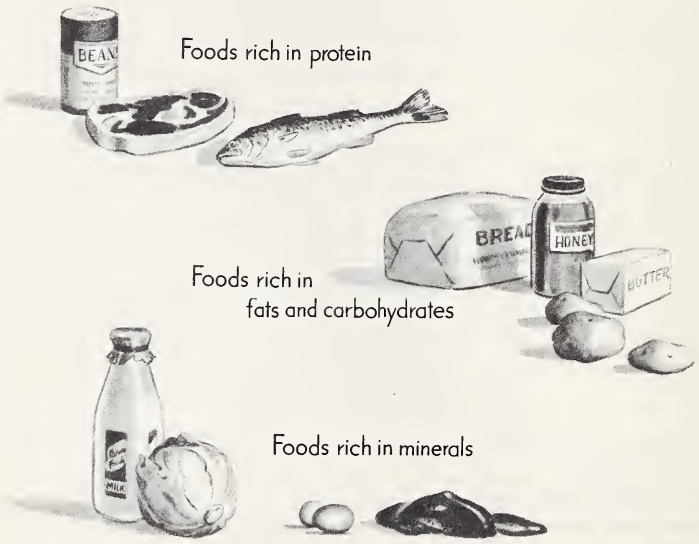
We can plan for more healthful ways in which to live together.

Information for You

You are familiar with the normal growth and development patterns of girls and boys, but many children are not. Perhaps you

will want to recall some of the essential developmental tasks of middle childhood so that you may allay children's fears concerning their rate of physical growth. Child development specialists today encourage us to acquaint children with the tasks confronting them so that they will be better able to approach these problems and reach solutions concerning them.

Proper food is necessary for optimum body growth. You will want to familiarize yourself with various groups of food essential to good physical development. Protein foods help new cells grow.



Foods rich in fats and carbohydrates give needed energy. Mineral-rich foods are important in the development of the skeleton and teeth. Water intake is necessary for proper elimination of waste materials. Vitamins play an important part in the efficient functioning of our bodies. A protective diet might include the following foods:

Milk and milk products
Whole-grain bread or cereal, or enriched white-flour bread
Meat, poultry, or fish, or dried beans, peas, or nuts
Eggs

Butter and/or other spreads, such as margarine, peanut butter
Oranges, grapefruit, or tomatoes
Green and yellow vegetables
Other fruit and vegetables

Perhaps you will want to think also of the developmental tasks of children involved in their relationships with other people. The subject matter of science is rich in opportunities for helping children understand themselves as human beings and in understanding other human beings.

Man is quite similar to other mammals in body structure. Yet he is very different in that he is able to think and plan, although this ability has not always been used in the wisest way or to the fullest extent. One of the first things we need to understand is that all races of men are fundamentally alike. All people are able to think and plan. The thinking ability of some people is greater than that of others, but all can plan and work together.

Evidence of planning exists all around you. People plan meals, vacations, work. Some groups of people are much interested in plant and animal conservation. Write your national, provincial, or state governments for free material on planning in this area.

Perhaps most of all we are interested in human conservation. We are interested in proper food, housing, clothing, recreation, and work facilities. We want to live in a peaceful world. All this takes planning and the responsible, active co-operation of all the people.

Ways of Working with Children

"We Live and Work Together" is independent of all other chapters in *Adventuring in Science*. You may wish to use the material throughout the year or at some specific time. Perhaps you will use sections of this chapter from time to time as problems arise among your children.

Use the introductory picture on pages 254–255 to initiate a consideration of growth changes. Help children to understand that the work and recreation needs of people vary with their ages.

Also, the picture on page 256 of *Adventuring in Science* may help clarify the idea that the size of various parts of the body changes in relation to the total body as one grows. Use a ruler to measure the heights and the head sizes of the man, older boy, and younger boy shown in this picture. Notice that the younger boy's

head is larger in proportion to his total height than is the older boy's head to his height, and the man's head to his height. A child's head grows as he becomes older, but it does not grow as much as do other parts of the body.

Help children to understand that they may be a little taller or a little shorter than their fathers or mothers. Help them to know that some children do not begin their growth spurt as early as others.

Some short children eat great quantities of food with the erroneous idea that this intake of food will help them grow taller rapidly. On the other hand, some tall children, especially girls, attempt to limit their food intake in an effort to check their growth. You will aid children in understanding that an adequate diet is necessary for good health.

All of us know that good health is important and that carefully selected foods help us to keep well. Our cafeterias should serve simple, well-cooked, healthful foods. If this is not true of your cafeteria, you and your group can help it serve better food. Or perhaps your children bring their lunches to school. Much can be done to improve the quality of most box lunches. Since it is usually parents who pack the lunch boxes, care must be taken in the way one goes about suggesting improvement. Perhaps you can help parents through bulletins, through conferences, and through their children to know the foods that make healthful box lunches. But under no circumstances will you undermine the faith of children in their parents.

If many of your children bring cold lunches, perhaps you will want to tackle the problem of serving hot soup for lunch. A group of children might be responsible for preparing soup each week. Perhaps mothers will be able to assist in this project.

The central theme in this chapter is conservation—conservation of human resources and of plant and animal resources. In addition to the information available in *Adventuring in Science*, children may want to obtain other information from government sources. Much of this kind of material is free or available at very low cost. Write and ask for a list of printed materials from the following sources or from your state or provincial government:

1. Department of Agriculture, Ottawa, Canada; material on experimental farm service and prairie farm rehabilitation.

2. Department of the Interior, Washington, D. C.; material on soil and forest conservation, dams, good farming practice, fish and game conservation.
3. Department of Resources and Development, Parliament Buildings, Ottawa, Canada; material on forest and soil conservation.

The school custodian can give helpful advice to children in their school-grounds-improvement activities.

Battle Creek Public Schools, Battle Creek, Michigan

Many communities are engaged in planning for better housing, play space, transportation, and educational facilities. Get in touch with your local authorities to find out about plans which are being made in your community.

Children should become aware that planning is going on. They need to learn about what is happening in the larger community. At the same time, they can work and plan in their school community. Plan with them concerning health habits. Let them assume some responsibility for the proper lighting and ventilation of the classroom. Let them help you plan a part or all of the day's and week's

work. Help them to become responsible for the appearance of the school building and grounds.

Above all, arrange your work so that the children have ample time and opportunity to *be* responsible and co-operative.

Materials Needed

government pamphlets on conservation

pictures of your children when they were younger

This Is for You

See suggestions for children, page 276, *Adventuring in Science.*

1—5. These activities are designed to encourage responsibility concerning one's self and one's environment.

6. The fire should never be built where it might ignite grass or trees. When the fire is no longer needed, scatter the embers, pour water on them, and cover them with sand or soil.

Further Activities

In order to develop further a sense of responsibility for the environment, you may want your children to engage in these activities:

1. Visit a farm to observe good conservation practices.

2. Visit a game preserve or bird sanctuary to observe ways in which animals are cared for.

3. If there is a tree farm near you, arrange to visit it and talk to the farmer.

4. Arrange a bulletin board to show kinds of food that are necessary for healthy bodies.

5. Arrange another bulletin board showing typical healthful menus for breakfast, luncheon, and supper.

6. Take a walk in your community. As new houses are built notice whether adequate space is left for recreation. Compare the new housing areas with older areas.

7. Build a model community with light, airy houses, good transportation and shopping facilities, churches, and adequate school and recreation facilities. This could be a rural or an urban community.

8. Plan ways to improve your schoolroom, building, and grounds. Are papers scattered about? If so, what can be done about it? Could shrubs and flowers be planted? What can you do about getting them in?

Was It Worth While?

If this study has been worth while, perhaps there should be evidence of changed behavior. Are your children more conscious of better ways to work together? Are they more responsible concerning the condition of their school? Do they use better judgment in choosing food for lunch? Is there greater willingness to settle problems through discussion?

Self-evaluation is a part of effective planning. Are children able to delineate areas in which they work more effectively with one another? Help your children to grow toward effective self-evaluation as an integral part of further planning.

If this period of evaluation occurs at the end of the year, perhaps you will want to think of the behavior of each child as he entered your group last fall. Has he demonstrated a greater awareness of his environment? Is he more responsible concerning it? Has he acquired new science facts? Does he use these facts as he is faced with new problems? Is there evidence of greater individual responsibility in relation to his classmates and the environment in which he lives?

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Films

ARTERIES OF NEW YORK CITY. (EBF) 1 reel, b/w. Describes the ways in which people plan together to regulate the traffic of a large city.

BREAD. (EBF) 1 reel, b/w. Presents the story of bread from wheat to loaf. Shows how many people work together to produce a loaf of bread.

BUILDING A HIGHWAY. (EBF) 1 reel, b/w. Illustrates the way in which many people work together, making use of many machines, in building a modern, two-lane highway.

BUILDING A HOUSE. (See film list for Chapter 8.)

CONSERVATION ROAD: THE STORY OF OUR NATURAL RESOURCES. (IF) 1½ reels, b/w. Shows how only a few people were once concerned about conservation, and how more and more people have joined together to promote good conservation practices.

CORN FARMER. (EBF) 1 reel, b/w. Illustrates how a typical corn farmer plans his year of planting, cultivating, and harvesting his crop.

DEER LIVE WITH DANGER. (EBF) 1 reel, color. Shows the struggle for survival among animals of the north woods.

FAIR PLAY. (WLF) 1 reel, color. Presents a Wyoming Fish and Game Commission film story of landowner-sportsmen relationship.

FOOD STORE. (EBF) 1 reel, b/w. Shows how a mother and her two children select the family's food in a modern food store. Pictures various kinds of foods used in the diet.

FOOD THAT BUILDS GOOD HEALTH. (Cor) 1 reel, b/w & color. Depicts the way in which a well-balanced diet contributes to strong, healthy bodies.

FOREST CONSERVATION. (See film list for Chapter 1.)

FORESTS AND CONSERVATION. (Cor) 1 reel, b/w & color. Pictures the critical problem of the wise use of forest resources. Depicts the work of a lumber company and a government agency in this direction.

FUNDAMENTALS OF DIET. (EBF) 1 reel, b/w. Discusses the food habits of various animals and the classes of food used by man. Emphasizes the importance of proper foods in man's diet.

GARDENING. (See film list for Chapter 5.)

GOOD EATING HABITS. (Cor) 1 reel, b/w & color. Proper eating habits, such as slow eating, thorough chewing, and proper food choice, are emphasized.

GRASSLAND. (See film list for Chapter 9.)

LEARNING THROUGH CO-OPERATIVE PLANNING. (TC) 1½ reels, b/w. Illustrates how elementary-school children can learn to participate as individuals in group undertakings.

MILK. (EBF) 1 reel, b/w. Describes the production and use of milk. Shows how many people work together to bring milk to our tables.

OUR SHRINKING WORLD. (YAF) 1 reel, b/w. Emphasizes the necessity of appreciating the problems of all the peoples of the world—a world in which we live together more and more closely.

SCIENCE AND SUPERSTITION. (Cor) 1 reel, b/w & color. Considers the problem of distinguishing between facts and common superstitions. Uses simple classroom projects to clarify this matter.

SEEDS OF DESTRUCTION. (EBF) 1 reel, color. Visualizes ways man has misused the resources of the forests. Suggests good methods of forest conservation.

SOIL AND WATER CONSERVATION. (UW-Govt) 1 reel, b/w. Shows soil conservation practices, including contouring, terracing, strip planting, and cover crop rotation.

TRUCK FARMER. (EBF) 1 reel, b/w. Shows how a truck farmer in the Rio Grande delta plans and carries out his farming activities throughout the year.

TWO LITTLE RATS AND HOW THEY GREW. (Dairy Coun St. Louis) 1 reel, color. Shows an experiment which fifth graders conduct with white rats to find out how food promotes growth.

Filmstrips

THE FIELD DAY (MAN CO-OPERATES WITH NATURE). (Curr F) color.

FOREST RESOURCES. (Curr F) color.

GROWING TREES FOR TOMORROW. (PDP) b/w.

HUMAN RESOURCES. (Curr F) color.

NATURE CO-OPERATES WITH MAN. (Curr F) color.

U.S. CONSERVATION SERVICE. (EGF) color.

WE PROTECT ANIMALS. (EGF) color.

WHY TREES ARE IMPORTANT. (PDP) b/w.

WILDLIFE CONSERVATION SET. (SVE) 4 filmstrips, color: WHAT THE SETTLERS DID TO WILDLIFE; PROBLEMS OF WILDLIFE TODAY; AIDING WILDLIFE OF FIELD AND STREAM; AIDING WILDLIFE OF WOOD LOT AND FOREST.

WILDLIFE RESOURCES. (Curr F) color.

Appendix

Minimum Science Equipment

This list of equipment is basic to the experiences suggested in *Adventuring in Science.* You and your children will be able to secure most if not all of it in your local community. A cupboard or shelves might be set aside in your classroom for the storage of this material. Your children will wish to help you collect, store, and care for this equipment.

Alcohol, rubbing
Ammonia, household

Baking powder
Baking soda
Balloons
Blueprint paper
Boric acid, powdered
Boxes, wooden fruit
Bridge lamp
Broomsticks, 2
Bulbs, 2 or 3 (1.5 volt), flashlight

Candles, large and birthday
Cardboard
Cheesecloth
Chrysalises
Cloth, dark-colored
Cocoons
Combs, pocket
Corks, assorted
Cornstarch
Cotton, absorbent
Cream of tartar

Dishes, 2 cereal
Dish, Pyrex
Dishpan
Doorbell, electric
Dry cells, 3 No. 6

Fish for aquarium
Flashlight
Flour
Flowerpots, assorted
Food coloring

Glass, various sizes, including 2 6-inch squares
Globe, of earth
Gravel

Hammer
Hand lens, or magnifying glass
Hatbox, oval
Hot plate, electric, or Sterno set

Iodine
Iron filings

Jar, large olive or pickle, for aquarium
Jars, 2 pint and quart

Knitting needles, 3 steel
Knives, paring

Litmus paper, pink and blue
Loam
Local stones
Lumber, assorted pieces, and 1 piece 5 feet long, and 1 piece 2 feet square

Magnets, bar and horseshoe
Map, North America
Matches, small boxes
Measuring cup
Measuring spoons
Measuring tape
Mirror, pocket
Modeling clay or plasticine

Nails
Newspapers

Pail
Pans, assorted
Paper, tissue
Paper towels
Ping-pong balls, 2
Plants for aquarium
Plaster of Paris
Plate
Pot holders

Rock collection
Rubber tube to fit teakettle spout

Salt, table
Saucers
Sawdust
Scissors
Screwdrivers
Screws
Seeds, Lima-bean, corn, grass, others
Shoe boxes
Shoe trees, 4
Skillet, old

Snails, for aquarium
Sockets, 2 miniature porcelain, for flashlight bulbs
Soda-water bottle
Spoons, 2 teaspoons
Spoons, 3 same size made of different materials
String
Sugar
Switches, knife and push-button

Tape, adhesive
Tape, 3 feet, electric insulation
Teakettle
Tennis ball
Thermometer, Fahrenheit
Thread, spool
Tumblers

Vinegar

Wire, 10 feet, insulated copper bell
Wire, 4 feet, iron picture
Wire, 12 inches, stiff but bendable
Wire screening, 3′ × 18″

Additional Science Equipment

The following materials may enable you to provide even richer experiences for your group. However, these materials are not essential to a good science program.

Aquarium with cover
Asbestos pads

Barometer, aneroid or Cape Cod
Blocks
Bulbs, assorted tulip, narcissus, etc.

Camera and films
Cages for animals
Compass

Electric fan

Fossil collection

Garden space and tools
Gloves

Map of world
Materials for making slides in the classroom (Keystone set or plastic slide materials and colored pencils)
Microscope
Models of trains, automobiles, ships, and airplanes

Paper for murals and booklets
Pie tins
Poster paints and brushes

Rock and mineral identification set
Sealing wax
Shellac
Sprinkling can
Stapler
Star maps
Terrarium
Wall hook
Window boxes, metal, to fit your windows
Wire shears

Equipment Supply Houses

The material which you will use in connection with *Adventuring in Science* usually may be secured from local stores. However, the following list of science equipment houses is given you in case you have need of material which you cannot secure from such stores. Most firms will furnish one catalogue to a school for the use of the teachers in that school.

CAROLINA BIOLOGICAL SUPPLY COMPANY, Elon College, North Carolina.
Living and preserved materials, plastic mounts, charts, and apparatus.

CENTRAL SCIENTIFIC COMPANY, 1700 Irving Park Boulevard, Chicago, Illinois; 79 Amherst Street, Cambridge A Station, Boston, Massachusetts, *or* CENTRAL SCIENTIFIC COMPANY OF CALIFORNIA, 6446 Telegraph Road, Los Angeles 22, California, *or* REFINERY SUPPLY COMPANY, 2215 McKinney Avenue, Houston 3, Texas, *or* CENTRAL SCIENTIFIC COMPANY OF CANADA, LTD., 146 Kendal Avenue, Toronto 4, Ontario, Canada.
General equipment—magnetism, heat, light, hand lenses and reading glasses, copper bell wire, etc.

CHICAGO APPARATUS COMPANY, 1735–43 North Ashland Avenue, Chicago, Illinois.
General equipment—magnetism, heat, light, etc. Aquarium and terrarium supplies, living and preserved materials, charts, etc.

FISHER SCIENTIFIC COMPANY, 711–723 Forbes Street, Pittsburgh, Pennsylvania, *or* EIMER AND AMEND, 633–635 Greenwich Street, New York, New York, *or* FISHER SCIENTIFIC COMPANY, LTD., 904–910 South James Street, Montreal, Canada.
General laboratory supplies and appliances.

GENERAL BIOLOGICAL SUPPLY HOUSE, 761–763 East 69th Place, Chicago, Illinois.
Aquarium and terrarium supplies, living and preserved materials, charts, etc.

NEW YORK SCIENTIFIC SUPPLY COMPANY, INC., 28 West 30th Street, New York 1, New York. (Formerly NEW YORK BIOLOGICAL SUPPLY COMPANY.)
Preserved and living materials, and chemicals.

SOUTHERN SCIENTIFIC COMPANY, INC., Atlanta 3, Georgia.
General equipment.

WARD'S NATURAL SCIENCE ESTABLISHMENT, INC., 3000 Ridge Road East, Rochester 9, New York.
Living and preserved materials and apparatus, rocks, and fossils.

W. M. WELCH SCIENTIFIC COMPANY, 1515 Sedgewick Street, Chicago 10, Illinois, *or* BRAUN, KNACHT-HEIMANN, 1400 16th Street, San Francisco 19, California.
General equipment.

Directory of Publishers

ALADDIN BOOKS (American Book Co.), 55 Fifth Avenue, New York 3, New York.

AMERICAN RED CROSS, National Headquarters, 17th and D Streets, N.W., Washington, D. C.

WM. C. BROWN COMPANY, Dubuque, Iowa.

CAPITOL PUBLISHING CO., INC., Irvington-on-Hudson, New York.

CHILDRENS PRESS, INC., Jackson Boulevard and Racine Avenue, Chicago 7, Illinois.

COWARD-MCCANN, INC., 210 Madison Avenue, New York 16, New York.

THOMAS Y. CROWELL COMPANY, 432 Fourth Avenue, New York 16, New York.

CROWN PUBLISHERS, INC., 419 Fourth Avenue, New York 16, New York.

THE JOHN DAY COMPANY, 210 Madison Avenue, New York 16, New York.

DODD, MEAD & COMPANY, 432 Fourth Avenue, New York 16, New York.

DOUBLEDAY & COMPANY, INC., 575 Madison Avenue, New York 22, New York.

THE DRYDEN PRESS, 31 West 54th Street, New York 19, New York.

E. P. DUTTON & CO., INC., 300 Fourth Avenue, New York 10, New York.

FUNK & WAGNALLS COMPANY, 153 East 24th Street, New York 10, New York.

GARDEN CITY BOOKS, Garden City, New York.

GINN AND COMPANY, Statler Building, Boston 17, Massachusetts.

GROSSET & DUNLAP, INC., 1107 Broadway at 24th Street, New York 10, New York.

HARCOURT, BRACE AND COMPANY, 383 Madison Avenue, New York 17, New York.

HARPER & BROTHERS, 49 East 33rd Street, New York 16, New York.

HARVARD UNIVERSITY PRESS, Cambridge 38, Massachusetts.

HOLIDAY HOUSE, 8 West 13th Street, New York 11, New York.

HENRY HOLT AND COMPANY, 383 Madison Avenue, New York 17, New York.

HOUGHTON MIFFLIN COMPANY, 2 Park Street, Boston, Massachusetts.

ALFRED A. KNOPF, INC., 501 Madison Avenue, New York 22, New York.

J. B. Lippincott Company, 227–231 South Sixth Street, Philadelphia 5, Pennsylvania.

Little, Brown and Company, 34 Beacon Street, Boston 6, Massachusetts.

Longmans, Green & Co., Inc., 55 Fifth Avenue, New York 3, New York.

Lothrop, Lee & Shepard Company, Inc., 419 Fourth Avenue, New York 16, New York.

The Macmillan Company, 60 Fifth Avenue, New York 11, New York.

Julian Messner, Inc., 8 West 40th Street, New York 18, New York.

William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, New York.

National Audubon Society, 1130 Fifth Avenue, New York 28, New York.

National Safety Council, Inc., 425 North Michigan Avenue, Chicago, Illinois.

Thomas Nelson and Sons, 19 East 47th Street, New York, New York.

Oxford University Press, Inc., 114 Fifth Avenue, New York 11, New York.

Random House, Inc., 457 Madison Avenue, New York 22, New York.

Rinehart & Company, Inc., 232 Madison Avenue, New York 16, New York.

Row, Peterson & Company, 1911 Ridge Avenue, Evanston, Illinois.

Roy Publishers, 30 East 74th Street, New York 21, New York.

Henry Schuman, Inc., 20 East 70th Street, New York 21, New York.

William R. Scott, Inc., 8 West 13th Street, New York 11, New York.

Charles Scribner's Sons, 597 Fifth Avenue, New York 17, New York.

Simon and Schuster, Inc., 630 Fifth Avenue, New York 20, New York.

William Sloane Associates, Inc., 425 Fourth Avenue, New York 16, New York.

Sterling Publishing Co., Inc., 215 East 37th Street, New York 16, New York.

Superintendent of Documents, Government Printing Office, Washington, D. C.

Vanguard Press, Inc., 424 Madison Avenue, New York 17, New York.

The Viking Press, 18 East 48th Street, New York 17, New York.

Franklin Watts, Inc., 699 Madison Avenue, New York 21, New York.

Whittlesey House (McGraw-Hill Book Company, Inc.), 330 West 42nd Street, New York 36, New York.

Wilcox & Follett Company, 1255 South Wabash Avenue, Chicago 5, Illinois.

Film and Filmstrip Distributors

Film Distributors

ALF	Almanac Films, Inc., 516 Fifth Avenue, New York 18, New York.
AUDUBON	National Audubon Society, Photo & Film Department, 1130 Fifth Avenue, New York 28, New York.
BARR	Arthur Barr Productions, 1265 Bresee Avenue, Pasadena 7, California.
BRAY	Bray Studios, Inc., 729 Seventh Avenue, New York 19, New York.
CALIF U	University of California, University Extension, Visual Department, 2272 Union Street, Berkeley, California.
CHURCHILL–WEXLER	Churchill-Wexler Film Productions, 801 North Seward Street, Los Angeles 38, California.
COMMONWEALTH	Commonwealth Pictures Corporation, 723 Seventh Avenue, New York 19, New York.
COR	Coronet Films, Coronet Building, Chicago 1, Illinois.
DAIRY COUN ST LOUIS	Dairy Council of St. Louis, 4030 Chouteau Avenue, St. Louis 10, Missouri.
EBF	Encyclopaedia Britannica Films, Inc., 1150 Wilmette Avenue and 1123 Central Avenue, Wilmette, Illinois; 101 Marietta Street, Atlanta 3, Georgia; 5745 Crabtree Road, Birmingham, Michigan; 161 Massachusetts Avenue, Boston, Massachusetts; 9794 Newton Avenue, Cleveland 6, Ohio; 1414 Dragon Street, Dallas 2, Texas; 5625 Hollywood Boulevard, Hollywood 28, California; 7421 Park Avenue, Minneapolis 23, Minnesota; 202 East 44th Street, New York 17, New York; 2129 N.E. Broadway, Portland 5, Oregon.
GE	General Electric Co., Distribution Section, Advertising & Sales Promotion, 1 River Road, Schenectady 5, New York.
HOLST	Kenneth L. Holst, 1399 North Lake Avenue, Pasadena 6, California.
IF	Instructional Films, Inc. See addresses given for EBF under Film Distributors.

KNOWLEDGE BLDRS	Knowledge Builders, 625 Madison Avenue, New York 22, New York.
LIBRARY FLMS	Library Films, Inc., 25 West 45th Street, New York 19, New York.
NY ZOOL	New York Zoological Society, 185th Street and Southern Boulevard, New York 60, New York.
PICTORIAL	Pictorial Films, Inc., 1501 Broadway, New York 19, New York.
STERLING	Sterling Films, Inc., 316 West 57th Street, New York 19, New York.
TC	Teachers College, Columbia University, Bureau of Publications, 525 West 120th Street, New York 27, New York.
TFC	Teaching Film Custodians, Inc., 25 West 43rd Street, New York 36, New York.
US BUR MINES	United States Bureau of Mines, Graphic Services Section, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.
US STEEL	United States Steel Co., 525 William Penn Place, Pittsburgh 30, Pennsylvania.
UW EDUC	Educational Film Department, United World Films, Inc., 1445 Park Avenue, New York 29, New York; 605 West Washington Boulevard, Chicago 6, Illinois; 7356 Melrose Avenue, Hollywood 46, California.
UW GOVT	Castle Films Department, United World Films, Inc., 1445 Park Avenue, New York 29, New York; 605 West Washington Boulevard, Chicago 6, Illinois; 7356 Melrose Avenue, Hollywood 46, California.
WLF	Wild Life Films, 5149–5151 Strohm Avenue, North Hollywood, California.
YAF	Young America Films, Inc., 18 East 41st Street, New York 17, New York.

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PDP	Pat Dowling Pictures, 1056 South Robertson Boulevard, Los Angeles 35, California.
SVE	Society for Visual Education, Inc., 1345 West Diversey Parkway, Chicago 14, Illinois.
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Instructional Films, Inc. See addresses listed for Encyclopaedia Britannica Films, Inc.

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Nu-Art Films, Inc., 112 West 48th Street, New York 19, New York.

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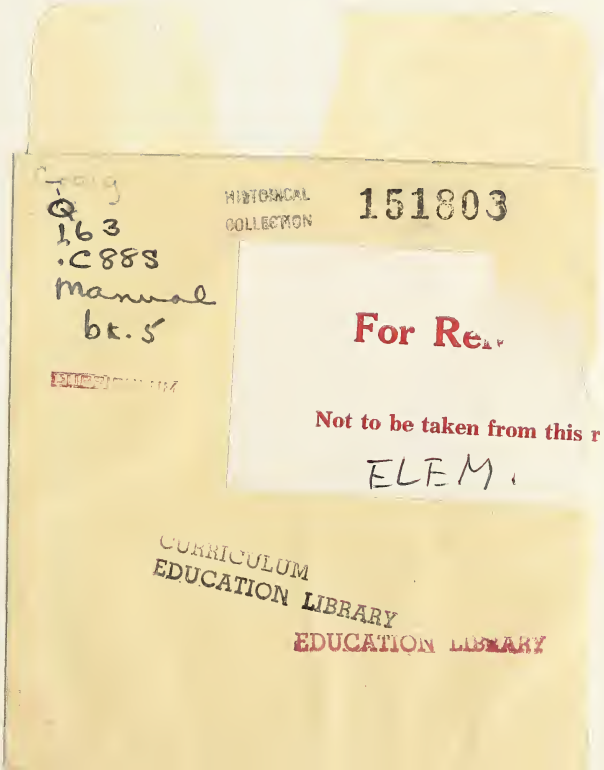

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